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Rocky Mountain Acid Deposition Model Assessment ARM3 Model Performance Evaluation

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In general, the model performance statistics indicate that the performance of the ARM3 is as good or better than the other mesoscale air quality models. However, care should be taken in the interpretation of these statistical measures. As noted in our analysis, the performance of a model varies depending on which measures of model performance are used: the model's ability to predict observations matched in time and location or the ability to predict peak observations.

Because resources were limited, the evaluation of ARM3 was limited in scope. In particular, because of a lack of an appropriate data base, the ARM3 could not be evaluated for its primary purpose, i.e., calculating source-specific acid deposition impacts in complex terrain. However, the fact that the model performs as good or better than existing mesoscale air quality simulation models indicates that the model shows some promise for use as a regulatory decision-making tool and should be further evaluated and refined.

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Abstract

The Acid Rain Mountain Mesoscale Model (ARM3), a hybrid acid deposition model, calculates short- and long-term acid deposition (sulfur and nitrogen) and PSD pollutant concentrations (SO_2 and TSP) resulting from emissions of a single source or group of sources at mesoscale distances in the complex-terrain of the Rocky Mountain region. The ARM3 consists of two principal components: a mesoscale meteorological model, which includes a diagnostic wind model, and a Lagrangian puff model, which treats transport, dispersion, chemical transformation, and wet and dry deposition. This modeling approach was guided by comments of members of the Western Acid Deposition Task Force (WADTF), who desired a computationally efficient model capable of calculating long-term source-specific acid deposition of nitrogen and sulfur in complex terrain.

Previous reports from the Rocky Mountain Acid Deposition Model Assessment Project reviewed existing mesoscale meteorological and acid deposition models for complex terrain; selected and evaluated candidate meteorological and acid deposition models for complex terrain; and provided the technical formulation and user's guide to the ARM3. Any model intended for use in regulatory decision-making must be evaluated. This report presents the evaluation of the ARM3.

The evaluation of the ARM3 was accomplished in several tasks:

> A diagnostic (or scientific) evaluation examined the formulation of the model by evaluating the parameterization of the major processes of acid deposition in the Rocky Mountains (transport, dispersion, chemical transformation, dry deposition, wet deposition). The diagnostic evaluation was part of the development of the model and is reported in a previous report.
>
> The wind model component of the ARM3 was evaluated separately. A preliminary evaluation was reported earlier, and a more complete evaluation is included in Appendix C of this report.
>
> The Lagrangian puff model component of the ARM3 (CONDEP) was compared with two EPA-approved Gaussian plume models: ISC and MPTER. This comparison is presented in Appendix A.
>
> The performance of the complete ARM3 modeling system was evaluated using tracer data from the Oklahoma and Savannah River Plant data sets. The model

performance was then compared with up to seven other mesoscale air quality simulation models.

In general, the model performance statistics indicate that the performance of the ARM3 is as good or better than the other mesoscale air quality models. However, care should be taken in the interpretation of these statistical measures. As noted in our analysis, the performance of a model varies depending on which measures of model performance are used: the model's ability to predict observations matched in time and location or the ability to predict peak observations.

Because resources were limited, the evaluation of ARM3 was limited in scope. In particular, because of a lack of an appropriate data base, the ARM3 could not be evaluated for its primary purpose, i.e., calculating source-specific acid deposition impacts in complex terrain. However, the fact that the model performs as good or better than existing mesoscale air quality simulation models indicates that the model shows some promise for use as a regulatory decision-making tool and should be further evaluated and refined.

Contents

Abstract ii

List of Figures vii

List of Tables viii

1 INTRODUCTION 1

- Goals and Objectives 4
- Organization of the Report 4

2 REVIEW OF EXISTING DATA BASES 6

- Evaluation of Meteorological Calculations 7
- Evaluation of Dispersion Calculations 10
- Evaluation of Chemical Transformation Calculations 16
- Evaluation of Surface Deposition Calculations 20

3 PREPARATION OF MODEL INPUT FILES 27

- Overview of Model Inputs Required 27
- Overview of the Tracer Experiment Data 30
- The Modeling Grid System 31
- Oklahoma Data Base 31
- Savannah River Plant Data Base 35
- ARM Simulation of the OK and SRP Experiments 37
- Postprocessing of the ARM3 Predictions 44

4 EVALUATION OF THE ARM3 45

- Model Performance for All Data 47
  - Oklahoma Data Set (Matched by Time and Location) 51
  - Savannah River Plant Data Set (Matched by Time and Location 51

Model Performance for the Highest Observations 52
  Data Unmatched by Time or Location 52
  Data Matched by Time But Not Location 54
Ranking of Model Performance 57
  Data Matched by Time and Location 60
  Data Unmatched by Time or Location 61
  Data Matched by Time But Not Location 63
  Final Ranking of the Models 64
5 SUMMARY AND RECOMMENDATIONS 66
References 68
Appendix A: Model Evaluation Protocol for the ARM3
Appendix B: Comparison of Results From the ARM3 With Results From Two EPA-Approved Gaussian Plume Models
Appendix C: Evaluation of the Diagnostic Wind Model
Appendix D: Scatterplots of Predicted and Observed Tracer Concentrations for Eight Mesoscale Air Quality Simulation Models and the Oklahoma Data Set
Appendix E: Scatterplots of Predicted and Observed Tracer Concentrations for Seven Mesoscale Air Quality Simulation Models and the Savannah River Plant Data Set
Appendix F: Predictions From Eight Mesoscale Models and Observations for the Oklahoma Data Set
Appendix G: Predictions From Seven Mesoscale Models and Observations for the Savannah River Plant Data Set

Figures

2-1 Primary ground-level sampling network for the ANATEX experiment 17

2-2 Location of significant source, meteorological, and receptor sites in the Savannah River Plant field study 18

2-3 Locations of the sequential air samplers (BATS) and aircraft sampling path at 100 km from the tracer release site in the Oklahoma field study 19

2-4 Atmospheric deposition monitoring networks in the U.S. 25

3-1 Flow diagram of ARM3 input and output files 28

3-2 Location of source, meteorological, and receptor sites for the Oklahoma data base 32

3-3 Location of source, meteorological, and receptor sites for the Savannah River Plant base 33

Tables

2-1 Tetroon studies suitable for wind model evaluation 8

2-2 A summary of near-source tracer studies of use in evaluating the ARM3 12

2-3 A summary of intermediate and long-range tracer experiments for use in evaluating the ARM3 15

2-4 A summary of plume chemistry transformation studies 21

2-5 Monitoring networks currently in the Annular Denuder System 24

2-6 Summary of major acid deposition data bases for evaluation of regional acid deposition models 26

3-1 A summary of grid characteristics used for the model evaluation 34

3-2 Availability and periods of record for the eight upper-air meteorological observation sites for the Oklahoma data base 36

3-3 A summary of options used in the meteorological preprocessor during the model performance evaluation exercise 38

3-4 A summary of the experiment times and dates modeled for the Oklahoma (a) and Savannah River Plant (b) evaluation study 39

3-5 A summary of model options utilized in the model performance evaluation exercise 43

4-1 Summary statistical model performance measures for the Oklahoma data base 49

4-2 Summary model performance statistics for the Savannah River Plant 50

4-3 Highest 25 predicted and observed tracer concentrations and the average of the 25 highest concentrations for the Oklahoma data set 53

4-4 Highest 25 predicted and observed tracer concentrations and the average of the 25 highest concentrations for the Savannah River Plant data set 55

4-5 Highest predicted and observed tracer concentrations for each sampling interval plus the average of the highest concentrations and correlation coefficient for the Oklahoma data set 56

4-6 Highest predicted and observed tracer concentrations for each sampling interval plus the average of the highest concentrations and correlation coefficient for the Savannah River Plant data set 58

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1 INTRODUCTION

The objective of the Rocky Mountain Acid Deposition Model Assessment Project is to assemble an acid deposition model from currently available air quality and meteorological models such that the new model can adequately describe the processes of acid deposition in the Rocky Mountain region. The model is intended for use by federal and state agencies in the western states to estimate concentrations and acid deposition impacts from proposed new sources. The model must be tested and evaluated before it is used to address regulatory air quality and acid deposition issues. The model must be reviewed by the U.S. Environmental Protection Agency (EPA) and evaluated according to the EPA Modeling Guidelines (EPA, 1986).

The guidelines for the design of the model consist of the following (Morris et al., 1987):

(a) The anticipated use of this model is to analyze permit applications and evaluate urban development plans. Thus the model is expected to simulate impacts of various air pollutants from both point and area sources.

(b) A typical modeling domain will cover approximately 200 km to 300 km on a side to have the ability to calculate impacts from new sources within relatively short distances (5-200 km) of Class I areas.

(c) The model should be able to handle events lasting long periods, i.e., be able to calculate seasonal and annual averages, in order to analyze cumulative impacts from both chronic and episodic events.

(d) The model should be able to simulate the transport, diffusion, transformation, and deposition of pollutants over complex terrain in the Rocky Mountain region using relatively sparse NWS upper-air soundings and routine surface observations.

(e) The model should be able to predict both Prevention of Significant Deterioration (PSD) pollutant concentrations impacts and deposition fluxes of sulfur and nitrogen species.

(f) Treatment of both gas- and aqueous-phase chemistry is desirable.

(g) The model should treat orographic effects on precipitation, including enhanced precipitation rates, snowfall, and ice-phase processes.

(h) The modeling system should be simple enough to be used by a regulatory agency with modest computer resources.

The resultant hybrid modeling system has been named the Acid Rain Mountain Mesoscale Model (ARM3) and was developed by adapting components of models presently in use. The design, algorithm selection, and formulation of ARM3 are described by Morris and co-workers (Morris and Kessler, 1987; Morris et al., 1987, 1988).

As the ARM3 system was being developed, different diagnostic evaluations of performance were made in order to objectively select various model algorithms that most realistically represented physical processes and were computationally efficient and statistically well behaved (Morris et al., 1987). Many of the algorithms incorporated in the model were tested using observed data. Upon completion of model development, a preliminary model evaluation was conducted; ARM3 calculations under simple conditions were compared with those of two EPA-approved models, MPTER-URBAN and ISCST-RURAL. This initial comparison of the ARM3 with the two EPA-approved models is presented in Appendix B.

Models approved by the EPA for regulatory use must meet the requirements for alternative models specified in the EPA modeling guidelines (EPA, 1986). For a model to be approved by the EPA for use in determining PSD increment consumption, or to show National Ambient Air Quality Standards (NAAQS) attainment, the model must demonstrate an ability to:

1. Be operated in a form equivalent to an EPA-approved model and produce the same results as the approved model (e.g., predictions within 2 percent of one another), or

2. Demonstrate better performance (measured statistically against observed data) than the most appropriate approved models, or

3. Provide suitably accurate and conservative model performance statistics for applications where no approved model would be appropriate.

The evaluation of the ARM3 under idealized conditions was designed to address the first of these three criteria. The results of that evaluation indicate that ARM3 can predict concentrations similar to the EPA-approved models ISCST-RURAL and MPTER-URBAN under a limited set of conditions. In fact, the model evaluation indicated that, on average, the concentrations predicted by ARM3 were between those predicted by ISCST-RURAL and MPTER-URBAN. This is most probably due to the fact that, as exercised, the ISCST uses rural (Pasquill-Gifford-Turner) dispersion parameters, while the MPTER-URBAN uses urban (McElroy-Pooler) dispersion values. The ARM3 dispersion parameters for complex terrain are generally between the urban and rural values.

Unfortunately, there is no adequate data base for evaluating the ARM3 within its intended region of application. Furthermore, funding for the evaluation of ARM3 as part of the Rocky Mountain Acid Deposition Project was only a third of the original estimate. Thus ARM3 was evaluated using tracer data bases for relatively simple terrain conditions, the same conditions used previously to evaluate eight long-range short-term regional transport models. Thus the ARM3 performance, is evaluated not only against tracer data, but also against up to seven existing regional transport models to determine the accuracy of the model compared to existing modeling techniques.

GOALS AND OBJECTIVES

This report is part of the Rocky Mountain Acid Deposition Model Assessment Project. Previous reports documented the review of existing mesoscale mdoels for simulating transport, dispersion, and deposition of pollutants in complex terrain (Morris and Kessler, 1987); the evaluation of models for use in complex terrain (Morris et al., 1988); and the formulation of and user's guide for ARM3 (Morris et al., 1988). The optional tasks of the Rocky Mountain Acid Deposition Model Assessment Project included the collection of data bases for use in running the ARM3 in the Rocky Mountain region and the evaluation of the ARM3.

ORGANIZATION OF THE REPORT

The EPA modeling guidelines require that the ARM3 be exercised using appropriate observed data and that its performance be compared with other EPA-recommended models. At the present time there are no EPA-recommended models for use in complex terrain or for analysis of acid deposition. Thus, to evaluate the ARM3 we have had to review pertinent model evaluation data bases, present a model evaluation protocol, and evaluate the major features of the ARM 3.

The ARM3 modeling system simulates the following major processes:

1. Meteorological processes
2. Pollutant dispersion
3. Chemical transformation
4. Pollutant deposition

In this report we will first review some of the data sets that can be used to evaluate each of the four major processes simulated by the ARM3, examining the attributes of each data set using some simple and practical criteria.

On the basis of the review findings, a model evaluation protocol was developed describing how the ARM3 would be evaluated (Appendix A). The elements of the protocol include:

- Discussion of the organization and goals of the model evaluation
- Data set selection
- Description of model performance attributes
- Discussion of model performance measures
- Description of the model performance evaluation methodology

Priorities have been recommended among the various elements of the model evaluation with the limited model evaluation resources.

The diagnostic wind model contained in the mesoscale meteorological component of the ARM3 was evaluated using data from an intensive measurement program in the South Central Coast region of California, which includes complex terrain (see Appendix C).

The complete ARM3 modeling system is evaluated against tracer data at two locations: Oklahoma and near the Savannah River plant in South Carolina. The ARM3 model performance of these two sites is compared with the performance of seven other mesoscale air quality simulation models in Section 4.

2 REVIEW OF EXISTING DATA BASES

Over the years a wide variety of field experiments have been conducted to collect data that could be used for either model development or model evaluation. These studies can be classified according to several basic categories. In our review we have excluded studies set completely in an urban airshed, as well as studies designed for evaluation of nondeterministic models. Air quality models and evaluation data sets can generally be divided into two groups based on the length of averaging involved. Short-term models simulate time periods short enough that emissions or meteorology can be treated as a steady state or with specific dispersion conditions. Long-term models simulate periods of several dispersion episodes or periods long enough that a wide variety of meteorological conditions occur. Short-term models commonly have averaging times from one hour up to several hours. Long-term models usually have averaging times of several days up to a year.

The ARM3 can calculate both short-term and long-term averages, and obtains long-term averages by simulating a series of short-term episodes. Most evaluations of short-term models use experiments where the receptors lie within several hours travel time of the source (< 50 km). Distances in long-range model evaluation extend from tens of kilometers to hundreds of kilometers.

The evaluation of the ARM3 should evaluate the performance of the model both near the source (< 50 km) and at intermediate (> 50 km) distances. Although the ARM3 is primarily designed to predict concentration and deposition impacts at intermediate distances, the evaluation of ARM3 predictions near sources should be a component of the model evaluation exercise. This is because almost all EPA-recommended models are near-source models and there have been more near-source field experiments. Thus an evaluation of ARM3 performance near sources will permit comparison of the ARM3 predictions with EPA-recommended models. This comparison with the EPA models is an important component of the evaluation.

Most of the data sets that we reviewed are generally suitable for evaluation of only one or two processes of the ARM3. For example, tracer experiments cannot be used to evaluate the modeling of chemical transformation or deposition processes. Likewise, data from acid precipitation chemistry networks are not appropriate for evaluating wind or dispersion processes. Because of the limitations in most field studies, the data sets we reviewed are grouped according to their applicability to evaluate a specific model process.

EVALUATION OF METEOROLOGICAL CALCULATIONS

The mesoscale meteorological module of the ARM3 generates gridded fields of winds mixing heights, temperatures, and other meteorological data at time intervals of approximately an hour. Since the ARM3 is designed to calculate source-specific concentration and deposition impacts, the highest priority in evaluating the ARM3 is to evaluate its ability to calculate source-receptor relationships. Of the meteorological inputs to the model, the most important to evaluate are the wind fields generated by the diagnostic wind model.

The evaluation of the diagnostic wind model in the ARM3 should focus on determining how accurately the modeled wind fields can reproduce observed trajectories. There are several ways of obtaining these observations:

Tetroon release and tracking experiments
High-resolution wind observations over simple (ideal) terrain features
Tracer experiments under situations where transport dominates over dispersion
Intensive meteorological measurement programs

Tetroon tracking studies would in principle provide ideal data for evaluating the wind model. A number of tetroon studies were conducted during the 1960s and 1970s. Some of these studies are summarized in Table 2-1. Several were conducted in either rolling or complex terrain. For example, the STATE tetroon study provides an excellent data base for comparing model-generated trajectories with observed data. No tetroon experiments have been conducted in the Rocky Mountains region. Unfortunately, resource limitations did not permit the evaluation of the transport compo-

TABLE 2-1. Tetroon studies suitable for wind model evaluation.

Study/Reference	Date/Sample Size	Location and Spatial Resolution	Experimental Method
STATE Study (Sulfur Transport and Transportation in the Environment) (Warner, 1981)	August 1978; 10 tetroons	Release point Cumberland Steam Plant, Tennessee; travel distance <25 (line of sight) and >250 km (touchdown point)	Tetroon positions were tracked by radar and point of touchdown. Typical elevation was 1000 m asl.
ARL Study (Allen and White, 1969)	May 1965 through June 1966; 552 flights, 117 recoveries	Release point Las Vegas; travel distance 1-4000 km	Tetroon positions were tracked by radar up to 12 hours, the recovery points were recorded. 72 cases were tracked 12 hours, 20 cases were tracked 24 hours. Typical balloon height was 3700 m asl.
WKY-TV tower (Hoeker, 1977; Angell et al., 1973)	September 25 - October 12, 1971; 56 tetroon flights, 16 recoveries	Release point southern Oklahoma City; travel distance 1-100 km; recovery points extend to 500 km.	Tetroons were set to float at 300 m agl (actually floated at 400 m). Position was tracked by radar. Recovery points were recorded.
Los Angeles Study (Angell et al., 1972)	September 9 - October 2, 1969; 105 tetroon flights	Release point Los Angeles Basin; travel distance 0-65 km	Tetroons were tracked by radar (1 minute average positions). The recovery locations were recorded as well. The tetroons were set to float at 200-400 m.

nent of the ARM3 (DWM). Instead, the available resources were focused on evaluating the integrated transport and dispersion components of the ARM3 and comparing the ARM3 predictive ability against other long-range transport models.

Relatively few field studies of flow over simple hills have sufficient observations to permit wind field models to generate accurate wind fields. Of the several experiments examined, only the Askervein Hill Project (Taylor and Teunissen, 1987) seems to provide high-resolution 10 - 50 m tower wind data. Most studies, of which Askervein is typical, are for terrain features that are typically on the order of 500-2000 m in height. While such studies are helpful in determining how the wind model may perform at small spatial scales around an ideal obstacle, they have little resemblance to the spatial scales and the complex geography in the Rocky Mountains region.

Tracer experiment data can be used to calculate plume trajectories. The major drawback of this method is that control over the position of a small volume of air is not great unless the puffs of tracer material disperse slowly. The tracer experiments with the greatest possible use in evaluating the peformance of a wind model would be those that include some supplemental wind observations at the ground and aloft, e.g., the DOE's Atmospheric Studies in Complex Terrain (ASCOT). One ASCOT study was conducted in the Brush Creek Valley of western Colorado to collect wind and tracer observations that could be used to evaluate a dispersion model for elevated point sources in deep canyons. (Other ASCOT tracer studies have been conducted at other locations but are generally of smaller spatial scale and hence less appropriate for evaluation of the ARM3 wind model.) The Brush Creek study (Whiteman et al., 1984) took place in a narrow (650 m) valley that is 25 km long. Unfortunately, such a narrow canyon would not be resolved by the 5-10 km grid spacing that is typical of ARM3 applications.

Intensive meteorological measurement programs can be used to evaluate the meteorological component of the ARM3 by using some of the wind measurements as input and holding back other observations for comparison with the model predictions. This method of evaluation has already been used in a preliminary evaluation of ARM3 using data from the Rocky Mountains (Morris et al., 1987). In addition, the wind model in the ARM3 has been evaluated using the many measurements collected as part of the south Central Coast Cooperative Aerometric Monitoring Program (SCCCAMP) in areas of ocean and complex terrain around Santa Barbara, California (Kessler and Douglas, 1988). Because there is some question whether a point measurement is comparable with the grid cell average flow vector calculated by the model, these types of evaluations are more diagnostic in nature.

In summary, of the four methods for evaluating the wind model component of the ARM3 system, only a tetroon experiment or an intensive measurement program would seem to be suitable for evaluating the performance of the wind model for complex terrain. The tetroon experiments are limited in sample size. In complex terrain the tetroons cannot be tracked by radar near the earth's surface, and they would strike the terrain if released at too low an altitude. The intensive measurement programs may provide the most suitable data for evaluating the ARM3 meteorological model, but still fundamental differences between the predictions and observations limit the comprehensiveness of the evaluation. It should be noted that an evaluation of the ARM3 model predictions against tracer data results provides an implicit assessment of the ability of the meteorological driver to simulate transport of the tracer plume.

EVALUATION OF DISPERSION CALCULATIONS

The evaluation of the dispersion calculations of a model such as the ARM3 could in principle use tracer experiments that possess sufficient meteorological data for the accurate representations of the wind fields.

Tracer tests can be classified according to the distance of the test. Near-source experiments examine dispersion within 50 km of the source. Intermediate-scale experiments are conducted over distances of 50 to 300 km from the source. Regional dispersion experiments extend the downwind distance from 300 to 2000 km. Tracer experiments covering longer distances are referred to as continental scale.

A large number of tracer experiments have been conducted very near the source (< 10 km). Information on these tracer tests has been assembled into a data base (Londergan et al., 1980). Most of these tracer tests are surface releases, with only a few receptors within of a few kilometers of the release point. Consequently, none of these tests seem suitable for evaluation of the ARM3.

Several tracer experiments have produced considerable information on the spatial distribution of concentrations at the ground and aloft, and have provided data for model evaluation studies. Near-source tracer data sets, exclusive of urban tracer studies, are summarized in Table 2-2.

The studies listed in Table 2-2 represent a wide variety of tracer experiments; several were conducted in complex terrain within the Rocky Mountain region. Of all of the studies, only the EPRI PMV&D tracer tests at Kincaid, Illinois, and Bull Run, Tennessee have been used to evaluate EPA-recommended models. The EPRI PMV&D data also include more extensive observational data, and more tracer observation hours, than the three tracer experiments conducted in the Rocky Mountain region. Of the complex-terrain sites, the Tracy, Nevada study (DeCristofaro et al. (1985) provides the largest amount and highest quality of tracer and meteorological data suitable for a model evaluation program. The Tracy data set is attractive because it has been used in model evaluation studies of EPA screening models, such as VALLEY, COMPLEX I and II, and RTDM, and it has a substantial number of tracer concentration hours for a variety of stability conditions. The chief disadvantage is the fact that all tracer sites lie within 10 km of the stack, and there is no systematic placement of fixed downwind distances because of logistical constraints. The Rocky Flats (Colorado) tracer study also has some attractive features. First, there are enough monitoring sites to study the dispersion of the tracer plume as a function of downwind distance. The observations are highly spatially resolved, down to the level of tens of meters, because of the rapid response time of the continous-flow electron capture chromatogram. The Brush Creek study does not seem very useful for ARM3 evaluation because the valley is so narrow, and the distances between the source and observations are generally less than those planned for ARM3 applications.

Some larger-scale tracer tests are listed in Table 2-3. Of these, only the Oklahoma and the Savannah River Plant tests seem suitable for evaluation of the ARM3 at intermediate soure-receptor distances. The Across North America Tracer Experiment (ANATEX) and Cross Appalachian Tracer Experiment (CAPTEX) have provided large amounts of data, but most data are for downwind distances beyond 300 km.

TABLE 2-2. A summary of near-source tracer studies of use in evaluating the ARM3.

Study/Reference	Date/Sample Size	Location and Spatial Resolution	Experimental Method
EPRI PMV&D (Plume Model Validation Development Study) (Reynolds et al., 1984)	March-September 1980 March-May 1981; 314 hours of SF_6 tracer, 35 weeks of SO_2, NO_x hourly data	Kincaid, Illinois; 28 SO_2, NO_x monitors; arcs at 0.5, 1.0, 2.0, 3.0, 5.0, 7.0, 10.0, 15.0, 20.0, 30.0, 40.0, 50.0 km with angular separations of 2-8 degrees	Site of a model evaluation study with elevated buoyant tracer release from stack. Colocated SO_2/SF_6 sites are available. Simple wind field in flat terrain with several instrumented meteorological towers and remote sensing of plume parameters available. The data were resolved to 5-minute averages. Tracers are resolved to 1 hour.
EPRI PMV&D (Plume Model Validation and Development Study) (Reynolds et al., 1985)	August-October 1982; 93 hours of SF_6 tracer observations spread over 12 tracer release experiments	Bull Run, Tennessee; arcs at 0.5. 1.0, 2.0, 3.0, 5.0, 7.0, 10.0, 15.0, 20.0, 30.0, 40.0, 50.0 km with angular separations of 1-8 degrees	Site of a model evaluation study with elevated, buoyant tracer release from stack. Site is located in rolling terrain. Four instrumented towers for wind data with remotely sensed plume parameters. With the exception of the tracer data, the data are resolved to 5-minute averages. Tracers are resolved to 1 hour.
NAWC western winter tracer programs (Griffith et al., 1988)	March 1985-March 1987; 3 experiments ~20 hours of release of hourly SF_6 observations	Beaver, Utah, and Mogollon Rim area, Arizona; 10 sequential samplers at Beaver site 7-40 km; aircraft flights 5-40 km	A real-time SF_6 monitor was flown in an airplane that made passes of the SF_6 plume at various downwind distances. All releases were surface releases. Five meteorological observation towers were used at the Beaver, Utah site.

Continued

TABLE 2-2. Continued

Study/Reference	Date/Sample Size	Location and Spatial Resolution	Experimental Method
NAWC Rocky Flats tracer study (Brown et al., 1988)	August 1987; 60 hours of aircraft data, 25 hours of mobile sampler data, > 200 syringe grab samples	Rocky Mountain Flats outside Denver, Colorado; aircraft and ground-level traverses.	A real-time SF_6 monitor was carried in an airplane and in a van. Meteorological data were recorded at the release site and two remote towers. Data are being collected for a model evaluation.
DOE ASCOT program (Orgill et al., 1984)	July-August 1987; approximately 20 hours of observations spread over 3 tracer experiments; 19 bag samplers in the valley; 12 hours of aircraft observations	Brush Creek Valley, Colorado Valley is 650 m wide 25 km long; monitors are scattered with a spacing of roughly 2 km down valley axis; a cross valley array of nearly a dozen monitors lies approximately 10 km downwind of the release point	Elevated (100 m agl) releases of SF_6 were made over 4-5 hour periods in early morning. Aircraft flights were made between 300-650 m above the valley floor. Five-second average samples were taken in the aircraft.

Continued

TABLE 2-2. Concluded.

Study/Reference	Date/Sample Size	Location and Spatial Resolution	Experimental Method
EPA Complex Terrain Model Development Study (D. C. DiCristofaro et al., 1985)	August 1984, 14 experiments 128 hours-11,609 concentration hours for 110 tracer samplers and 3 elevated samplers on 150 m tower	Tracy, Nevada; 6 sites <2 km; 29 sites 2-4 km, 45 sites 4-6 km, 26 sites 6-8 km, 4 sites 8-10 km; sites are concentrated in 40-160° sector and 200-300° sector; lidar (ground based) 2.2 km from plant; aircraft lidar made transects from 0-10 km downwind in a ladder pattern.	This was the site of a model evaluation study for VALLEY, COMPLEX-I and II, RTDM, and CTDM. Three tracers (oil fog, SF_6, and CF_3Br) were released from a buoyant, elevated power plant stack. The site was located in complex terrain on the eastern slope of the Sierra Nevada. The data are resolved to 1-hour averages. Meteorological variables were collected for 7 levels from a 150 m tower, from four 10 m towers, and from 2 portable weather stations. Two tethersondes, 3 acoustic sounders, and 2 radar-tracked balloons (RABALs).

TABLE 2-3. A summary of intermediate and long-range tracer experiments for use in evaluating the ARM3.

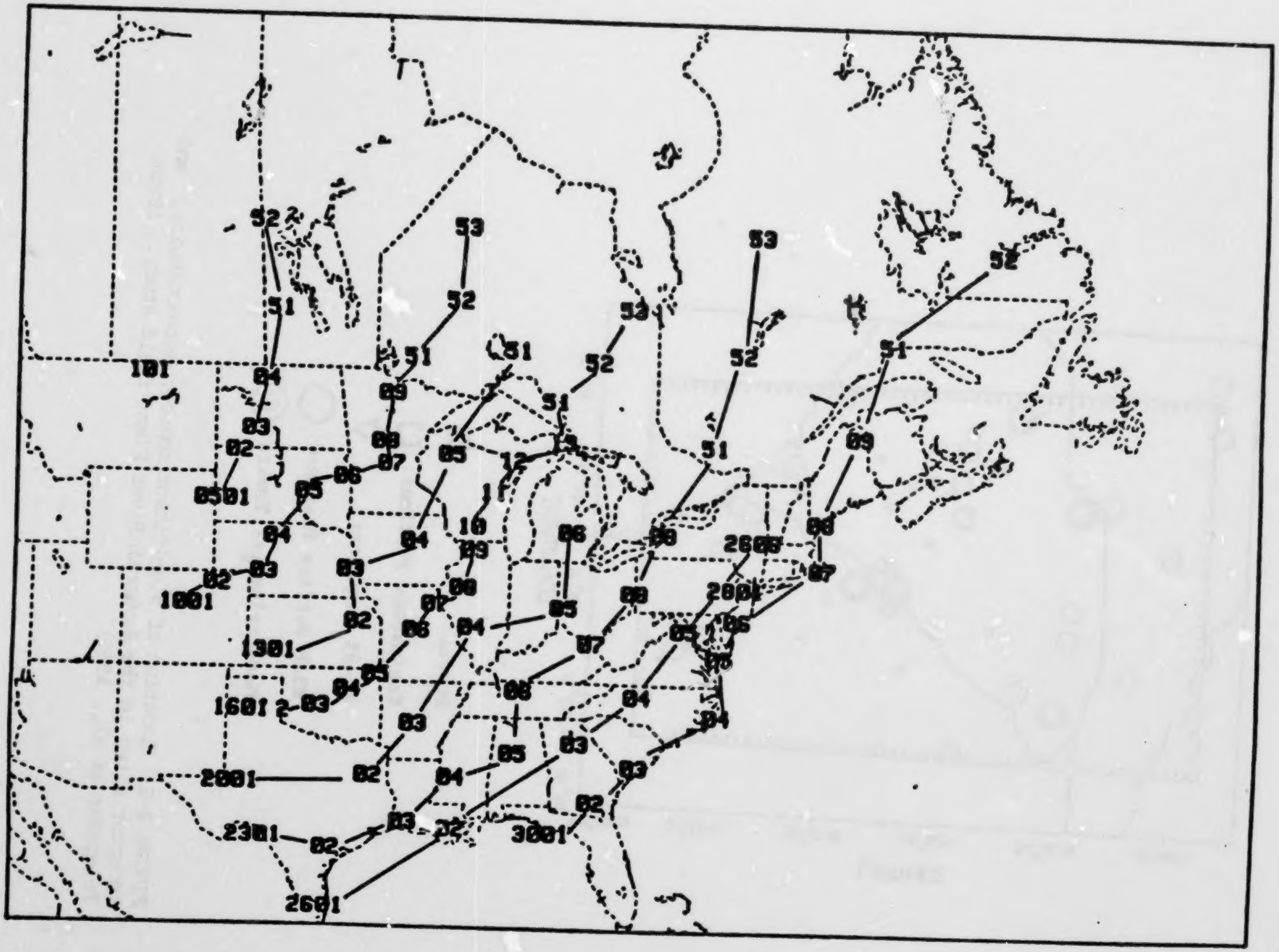
Study/Reference	Date/Sample Size	Location/Spatial Resolution	Experimental Method
NOAA Oklahoma long-range perfluorocarbon tracer experiment (Ferber et al., 1981)	July 8, 1980; 30 samples for 7 hours at 100 km; 62 hours for 38 samples at 600 km; 18 grab samples at 100 km; 19 grab samples at the 600 km arc	Norman, Oklahoma release point, two arcs, one at 100 km and the other at 600 km; roughly 5 km resolution at 100 km and 20 km 600 km arc	Ground-level releases for 3-hour periods (1400-1700 EDT) of five tracers--C_7, F_{14}, C_8, F_{16}, SF_6, $^{12}CD_4$, $^{13}CD_4$. Wind observations aloft were obtained from the KTVY tower at 7 levels and a special rawinsonde was released in the morning at Tinker AFB. Data were used in short-term, long-range transport model evaluation (Policastro et al., 1986).
NOAA Savannah River Plant Krypton-85 releases (Telegadas et al., 1980)	October 1976 to July 1977; 15 experiments with a total of 65 10-hour averaging periods for 13 sites	Savannah River Plant, Aiken, South Carolina; 13 monitors ranging from 28 km to 144 km from the source stacks (two stacks separated by 4 km)	Krypton-85 releases were from elevated points in a gently rolling countryside. 10-hour averaged samples were collected. Meteorological data were available from 7 meteorological towers and 26 surface stations within the study region. Upper-air data from 4 NWS rawinsonde release sites.
CAPTEX-83, Cross-Appalachian Tracer Experiment (Clark et al., 1984) (Draxler et al., 1986)	September to October 1983--3000 surface samples and 1600 aircraft transect samples for 7 experiments (5 from Dayton, 2 from Sudbury)	Dayton, Ohio and Sudbury, Ontario; 9 arcs from 300 km to 1100 km in 100 km increments; station spacing ranges from 50 km on inner arcs to 70-120 km on the outermost arcs	Tracer was released at ground level for 3-hour periods. Seven aircraft from PNL, BNL, and EAS were used to make sequential samples. One aircraft was equipped with a real-time analyzer. Upper-air soundings were increased to 4 per day in regions where tracer material was detected. Meteorological data was collected at 8 special towers at levels ranging from 9 to 230 m.
ANATEX - Across North American Tracer Experiment (Draxler and Heffter, 1989)	January 5 to March 29, 1987; 7500 samples from 77 primary sites and 12 remote sites with 33 3-hour release experiments	Glasgow, Montana, and St. Cloud, Minnesota; 77 sites extending from 200 m to 3000 km; typical interstation spacing of 50-300 km	During this period the ground-level sequential samplers took 24-hour averages. Three aircraft obtained samples aloft within 500 km of the release sites; 42 2- or 4-hour sorties were flown during the program. Aircrafts flew below 1500 m. Five observation sites made observations at the ground and at 200 m. During the release days, four rawinsonde releases and four upper-air sites were added within 500 km of the release site.

Both the ANATEX and CAPTEX data sets have measurements in both simple and moderately complex terrain. ANATEX conducted ground-level tracer releases every 2.5 days for three months (January-March 1987) from two release sites: Glasglow, Montana, and St. Cloud, Minnesota. Measurements were made at arcs as far away as 3,000 km (see Figure 2-1). The CAPTEX program consisted of six tracer releases from Dayton, Ohio, and Sudbury, Ontario and was designed to provide data for evaluating dispersion models for distances of 300 to 1200 km. The tracer data from the ANATEX and CAPTEX experiments have too coarse a resolution and at too large a scale to be useful in evaluating the ARM3.

The Savannah River Plant experiments were conducted over gently rolling terrain, while the Oklahoma experiment took place over nearly flat terrain in the Midwest. The downwind distance of most monitors in the Savannah River Plant experiment (Figure 2-2) are ideally suited for evaluating the performance of ARM3 for its intended use. Of the Oklahoma sites, the data from the monitors at the 100 km arc (Figure 2-3) would be most useful in evaluating ARM3 performance. The next arc, at 600 km, may provide some diagnostic information on the performance of the ARM3 transport and dispersion algorithms but it exceeds the source-receptor distances ARM3 is expected to model. A definite advantage of the Oklahoma and Savannah River Plant data is that eight short-term, long-range transport models have been evaluated using these data (Policastro et al., 1986a). Five of the models are listed in Appendix B of the EPA modeling guidelines as EPA-alternative models (EPA, 1986). The importance of selecting tracer data bases that have already been used for model evaluation studies cannot be overemphasized. The existence of a bench mark model evaluation for a data base greatly enhances the interpretation of model performance. Without this information it is hard to distinguish the factors contributing to a model's performance for a given data set.

EVALUATION OF CHEMICAL TRANSFORMATION CALCULATIONS

Evaluations of chemical transformation algorithms are difficult to do outside of laboratory reaction chambers, for the reason that it is difficult to separate the effects of chemical transformation from those of dispersion and other meteorological processes. Such experiments require (1) simultaneous-releases of inert and


101
52
51
04
03
02
0501
1001
53
52
51
09
08
07
06
05
04
03
02
1301
1601
2001
2301
2601
51
12
11
10
09
08
07
06
05
04
03
02
53
52
51
06
05
04
03
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3001
53
52
51
08
07
06
05
04
03
2601
2801
52
51
09
08
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06
05
04

FIGURE 2-1. Primary ground-level sampling network for the ANATEX experiment. The exact location of each monitor is at the center of the site number. (From Draxler and Ferber, 1989.)

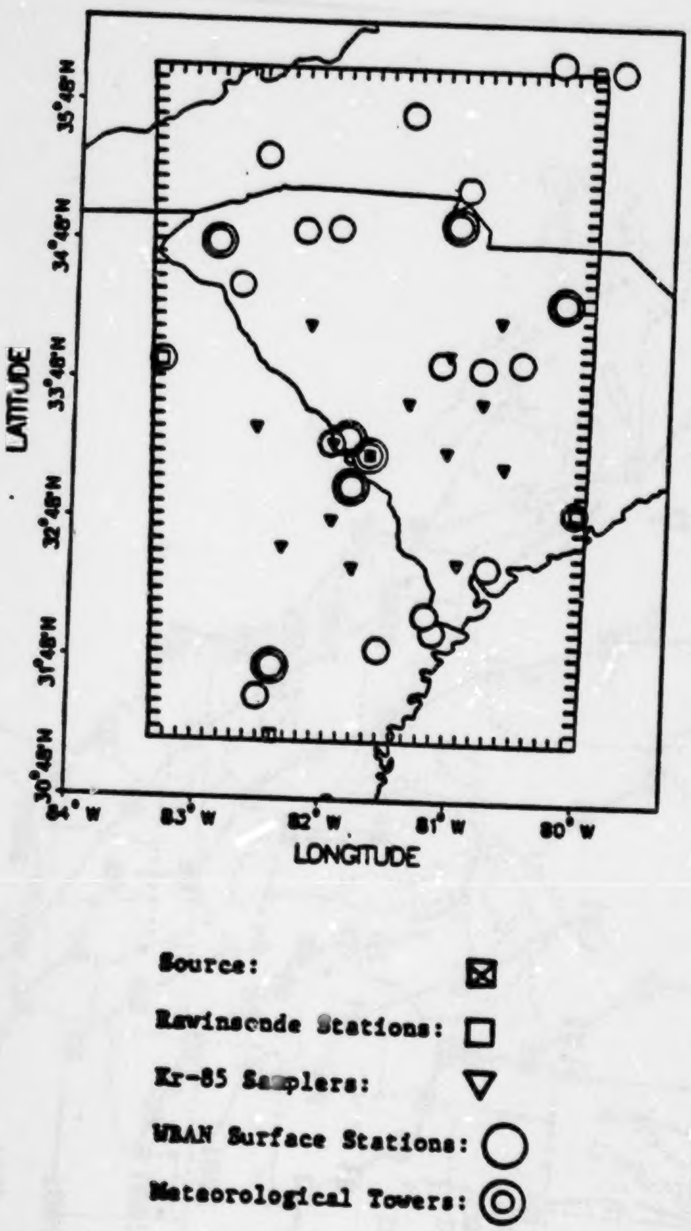
35°48'N
34°48'N
33°48'N
32°48'N
31°48'N
30°48'N
LATITUDE
84° W
83° W
82° W
81° W
80° W
LONGITUDE
Source: ⊠
Ravinsonde Stations: □
Kr-85 Samplers: ▽
WBAN Surface Stations: ○
Meteorological Towers: ◎

FIGURE 2-2. Location of significant source, meteorological, and receptor sites in the Savannah River Plant field study. (From Telegadas et al., 1980)

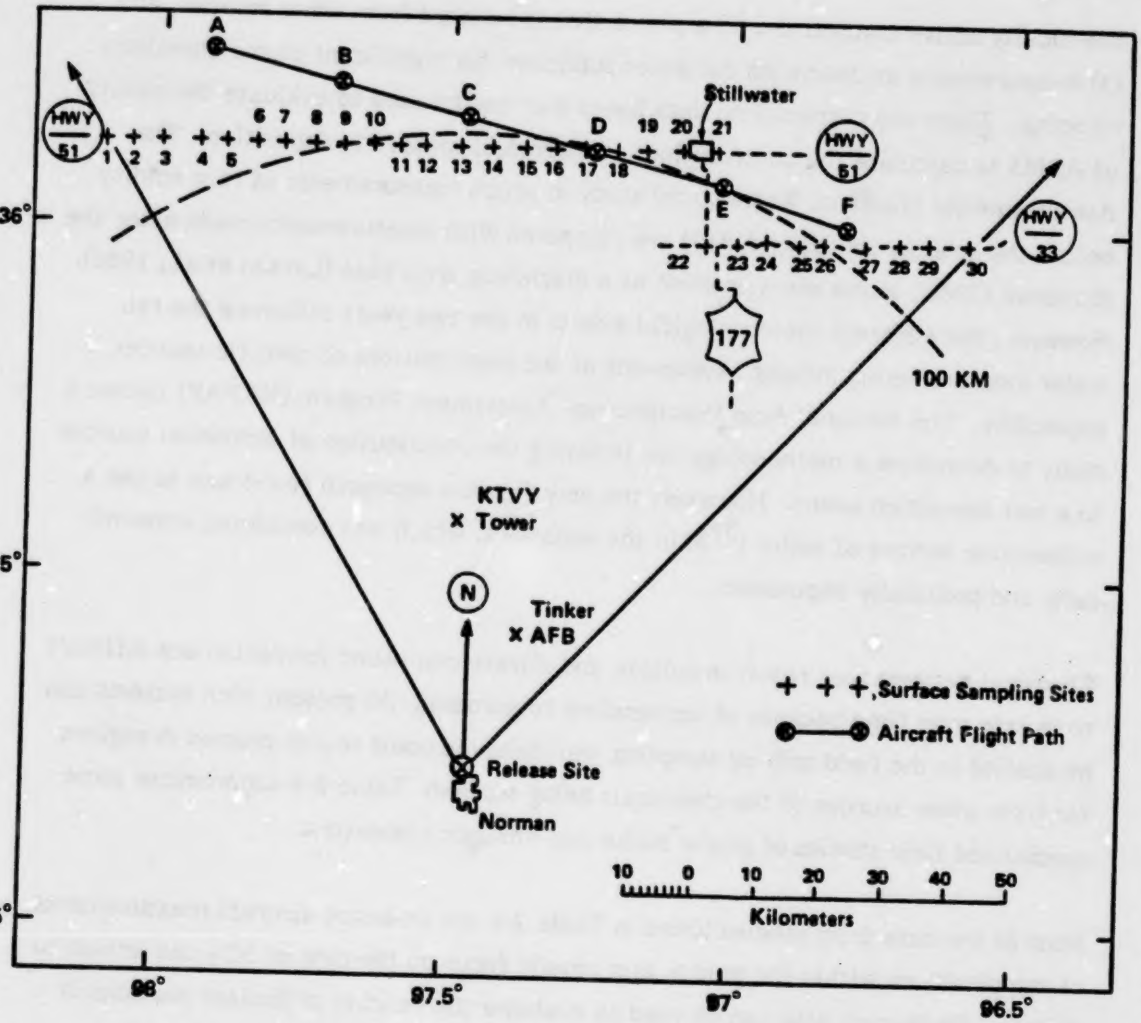
A
B
C
D
E
F
Stillwater
HWY 51
HWY 51
HWY 33
177
100 KM
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
22 23 24 25 26 27 28 29 30
36°
35.5°
35°
98°
97.5°
97°
96.5°
KTVY
× Tower
N
Tinker
× AFB
+ + +, Surface Sampling Sites
Aircraft Flight Path
Release Site
Norman
10 0 10 20 30 40 50
Kilometers

FIGURE 2-3. Locations of the sequential air samplers (BATS) and aircraft sampling path at 100 km from the tracer release site in the Oklahoma field study. (From Ferber et al., 1981)

chemically active compounds, (2) a plume that is isolated from other sources, and (3) measurements at downwind distances sufficient for significant plume chemistry to occur. There are currently no data bases that can be used to evaluate the ability of ARM3 to calculate the contributions of individual sources to deposition. The Asarco smelter (Tacoma, Washington) study in which measurements of rain acidity before the smelter shutdown (1985) are compared with measurements made after the shutdown (1986), shows some promise as a diagnostic data base (Larsen et al., 1986). However, the different meteorological events in the two years influence the rain water measurements, making assessment of the contributions of specific sources impossible. The National Acid Precipitation Assessment Program (NAPAP) funded a study to determine a methodology for isolating the contribution of individual sources to a wet deposition event. However, the only feasible approach found was to use a radioactive isotope of sulfur (^{35}S) in the emissions, which was considered economically and politically impossible.

Chemical systems that result in sulfate and nitrate compound formation are difficult to isolate over time because of conversions to aerosols. At present such systems can be studied in the field only by sampling well-behaved point source plumes in regions far from other sources of the chemicals being studied. Table 2-4 summarizes some specialized field studies of plume sulfur and nitrogen chemistry.

Most of the data from studies listed in Table 2-4 are on-board aircraft measurements of samples from within the plume, and usually focus on the rate of SO_2 conversion to sulfate. While such data can be used to evaluate the validity of limited portions of the ARM3 chemistry, there is at present no EPA-recommended model that can be compared to the chemistry module in the ARM3.

EVALUATION OF SURFACE DEPOSITION CALCULATIONS

As noted above, there have been no experiments that have isolated the contribution of a single source to wet or dry deposition measurements. All available wet deposition measurements are cumulative (source plus background). Since the ARM3 is predicting the contribution of a single source, it is impossible to operationally evaluate the model's ability to predict wet deposition in the Rocky Mountains. A regional-

TABLE 2-4. A summary of plume chemistry transformation studies.

Sponsor/Study/Reference	Study Area and Sample Set Description	Models, Variables, and Averaging Period	Experiment Description
Project MISTT (Midwest Interstate Sulfur Transformation and Transport) (Gilliani et al., 1978; Husar et al., 1978)	Labadie Power Plant St. Louis; 1976; ~10 flight-days in July-August; ~50 samples; 2 aircraft.	SO_2, SO_4, aerosols, O_3, b_{scat}, NO_x averages for 15-60 minutes flight time; Aitken nuclei counts were also made.	Aircraft made horizontal traverses and vertical soundings at discrete downwind plume sections ranging from 30-100 km. Aircraft measurements of turbulence, RH, and temperature are available. Data from RAPS on meteorology was available for the study. Plume width and height estimates are available.
NOAA/Four Corners Study (Pueschel and Valin, 1978)	Four Corners Power Plant, Farmington, New Mexico; July-October 1975, February-October 1976; 18 days of flights, 4 days of data, 9 data points.	SO_2, CCN, O_3, NO_x, b_{scat}, Aitken nuclei count; averaging time was sample dependent.	Aircraft made flights through the plume from 10 to 80 km downwind with flights lasting from 2-4 hours.
TVA/STATE Tennessee Valley Plume Study (Forrest et al., 1981)	Cumberland Steam Plant, Stewart County, Tennessee; 12 flights on August 18-24, 1978; 20 samples range in downwind distance from 11-200 km.	No models were evaluated; the variables measured included total S, particulate S, O_3, total NO_3, b_{scat} NH_4; sampling occurred over a 30-60 minute time period.	Aircraft flew through the Cumberland plume taking chemical measurements, and also measuring temperature, relative humidity, and total radiation. Tetroons were released from the stack and tracked by radar. Surface observations of wind and other meteorological variables are available from the meteorological tower at the Cumberland plant. Plume width and height estimates are available.

Continued

TABLE 2-4. Concluded

Sponsor/Study/Reference	Study Area and Sample Set Description	Models, Variables, and Averaging Period	Experiment Description
EPA/VISTTA (Visibility Impairment Due to Sulfur Transport and Transformation in the Atmosphere) (Blumenthal et al., 1981; Seigneur et al., 1980)	Navajo Generating Station, Page, Arizona; June 26-14 July, December 1-16, 1979; 0-100 km, 2-3 distances per flight; approximately 40 hours of flight measurements.	PLUVUE, variables measured included NO, SO_2, O_3, NO_x/b_{scat} aerosol size distribution. Aitken nuclei count. Averaging period is typically 1 hour.	Both aircraft and fixed ground sites (2) made observations of plume concentrations, plus RH, turbulence, temperature, and solar radiation. Wind observations and other meteorology were available from a mobile weather station. Upper-air soundings are available every 4 hours from Page, AZ. The plume width, height, and location are available for selected flights.
DOE/Northpont Plume Study (Garber et al., 1981)	Northpont Power Station, Long Island, NY; plume traverses at 0.5 to 40 km downwind; 62 experiments for a total of ~150 hours.	No models were evaluated; variables measured include SO_2, SO_4, total S, and particulate S; sampling was done over a 20-40 min period (O_3, NO_x, other parameters are available on some flights)	Aircraft flights also collected RH and temperature. Pilot balloons were released during flights to give wind profiles, and meteorological data from NWS and plant meteorological tower are available. Flights were made during a wide range of meteorological conditions.

scale modeling study of the western states (Latimer et al., 1985) indicated that, based on annual averages, less then 2 percent of the sulfate and 12 percent of the nitrate concentrations at the Flat Tops Wilderness Area came from sources within Colorado (Pielke, 1986).

Precipitation chemistry data from the western U.S are available from several sources. Most of the observing networks, such as the NADP network, make precipitation chemistry observations once a week (Table 2-5). Approximately eight monitors in the Rocky Mountain region of Colorado and Wyoming are part of the NADP monitoring network (Figure 2-4). However, as noted above, the usefulness of this data for evaluating the ARM3 is somewhat questionable.

For the most part, the networks listed in Table 2-5 are designed to provide data for the evaluation of long-term models. However, some specialized studies do measure short episodes of wet deposition (Table 2-6). In addition, an acid deposition measurement program covering the eastern U.S. and Canada, designed to create a data base for the evaluation of the Regional Acid Deposition Model, will be started in 1989 to 1990. The complexity and cost (many millions of dollars) of this effort underscores the difficulty in evaluating acid deposition models and the inadequacy of existing data bases.

Measurement techniques of dry deposition of sulfur and nitrogen compounds have not advanced to the point where direct observations can be made. Most methods of estimating dry deposition are indirect, based on inference from other measurements, and require many of the same assumptions as do the algorithms used to predict dry deposition. The only means of evaluating dry deposition algorithms is to infer dry deposition rates from observations of ambient concentrations.

TABLE 2-5. Monitoring networks currently in the Annular Denuder System. (From NAPAP, 1986)

NETWORK	GEOGRAPHICAL AREA	PERIOD OF OPERATION AND NUMBER OF SITES	NO. OF SITES IN 1985	SAMPLING PERIOD	PARAMETERS MEASURED
National Atmospheric Deposition Program (NADP)	National coverage of United States	Began in 1978 with 22 sites. Operation continuing for increased number of sites.	193	Weekly samples collected each Tuesday.	pH, conductivity, $SO_4^=$, NO_3^-, NH_4^+, Cl^-, $PO_4^=$, K^+, Na^+, Ca^{++}, Mg^{++}.
National Trends Network (NTN)	National coverage of United States	Began in 1982. Includes many NADP sites. Reached full implementation (150 sites) in 1985.	150	Weekly samples collected each Tuesday.	pH, conductivity, $SO_4^=$, NO_3^-, NH_4^+, Cl^-, $PO_4^=$, K^+, Na^+, Ca^{++}, Mg^{++}.
Canadian Network for Sampling Precipitation (CANSAP)	National coverage of Canada	Began in 1977 with 45 sites. Operation to end Jan. 1, 1986.	27	Monthly samples collected on last day of month.	pH, conductivity, $SO_4^=$, NO_3^-, NH_4^+, Cl^-, K^+, Na^+, Ca^{++}, Mg^{++}.
Canadian Air and Precipitation Monitoring Network (APN)	Eastern Canada	Began in November 1978 with 5 sites. 4 sites became part of CAPMoN.	1	Daily samples.	pH, $SO_4^=$, NO_3^-, NH_4^+, Cl^-, K^+, Na^+, Ca^{++}, Mg^{++}, total phosphorus.
Acidic Precipitation in Ontario Study (APIOS) Cumulative Network	Ontario Province	Began in September 1980.	34	4 weekly samples.	pH, $SO_4^=$, NO_3^-, NH_4^+, Cl^-, K^+, Na^+, Ca^{++}, Mg^{++}, total Kjeldahl nitrogen, total phosphorus and trace metals.
Acidic Precipitation in Ontario Study (APIOS) Daily Network	Ontario Province	Began in September 1980.	14	Daily samples.	pH, conductivity, $SO_4^=$, NO_3^-, NH_4^+, Cl^-, Na^+, Ca^{++}, Mg^{++}, acidity.
MAP3S Precipitaiton Chemistry Network (MAP3S/PCN)	Eastern United States	Began operation in 1976 with 5 sites.	9	Event samples.	pH, conductivity, $SO_4^=$, NO_3^-, NH_4^+, Cl^-, K^+, Na^+, Ca^{++}, Mg^{++}, $PO_4^=$, NO_2^-, $SO_3^=$.
Utility Acid Precipitaiton Study Program (UAPSP)	Eastern and Central United States	Began operation in October 1981.	21	Daily samples.	pH, conductivity, $SO_4^=$, NO_3^-, NH_4^+, Cl^-, K^+, Na^+, Ca^{++}, Mg^{++}, $PO_4^=$, strong acids, total acids.
Canadian Air and Precipitation Monitoring Network (CAPMoN)	Eastern Canada	Began operation in Mid-1983.	23	Daily samples.	pH, conductivity, $SO_4^=$, NO_3^-, NH_4^+, Cl^-, K^+, Na^+, Ca^{++}, Mg^{++}, alkalinity, acidity.
Tennessee Valley Authority (TVA)	Tennessee Valley	Began operation in 1977.	9	Every 2 weeks.	pH, conductivity, $SO_4^=$, NO_3^-, NH_4^+, Cl^-, K^+, Na^+, Ca^{++}, Mg^{++}, $PO_4^=$, strong acids, weak acids.
EPA Region IV	Southeast United States	Began operation in 1982.	11	Weekly.	pH, conductivity, $SO_4^=$, NO_3^-, NH_4^+, Cl^-, $PO_4^=$, K^+, Na^+, Ca^{++}, Mg^{++}.
Great Lakes Atmospheric Deposition Network (GLAD)	Great Lakes Region	Began operation in 1981.	36	Weekly.	pH, conductivity, $SO_4^=$, NO_3^-, NH_4^+, Cl^-, $PO_4^=$, K^+, Na^+, Ca^{++}, Mg^{++}, trace metals.
Wisconsin Dep. Monitoring Net. (WISC)	Wisconsin State	April 1982 to June 1984	3	Daily samples.	pH, conductivity, $SO_4^=$, NO_3^-, NH_4^+, Cl^-, K^+, Na^+, Ca^{++}, Mg^{++}.

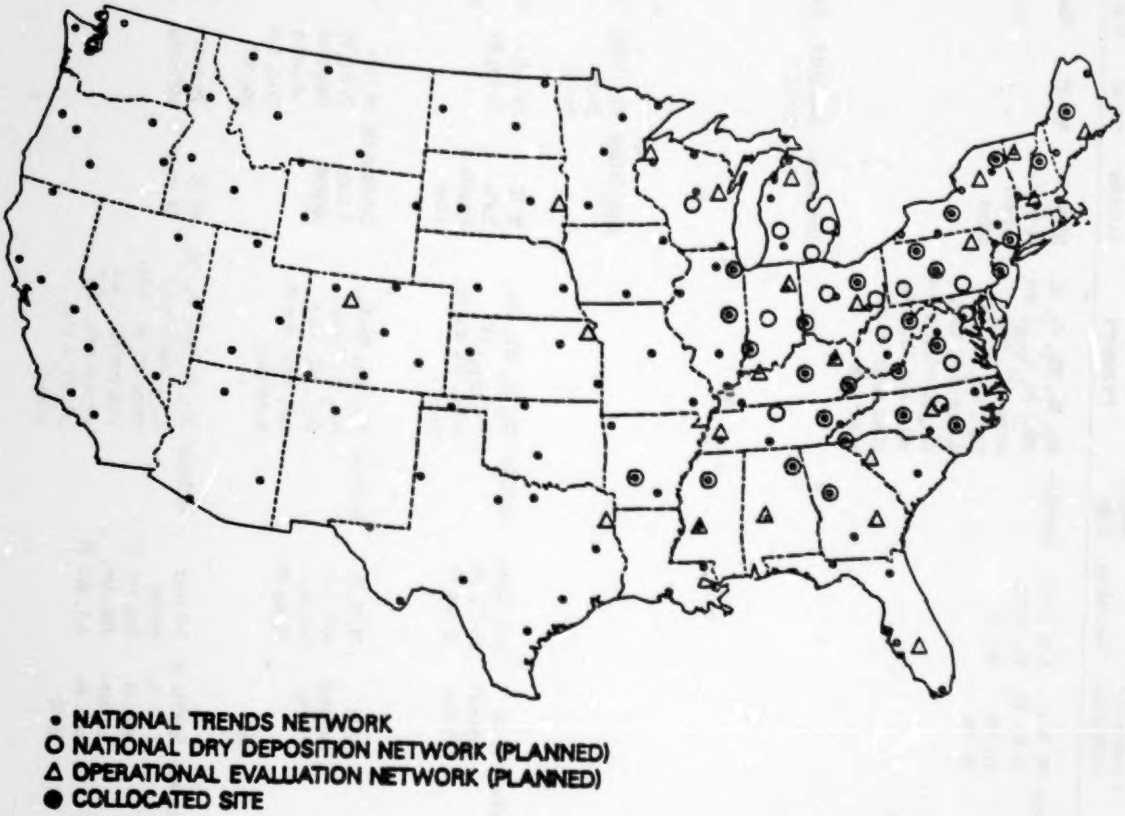
• NATIONAL TRENDS NETWORK
○ NATIONAL DRY DEPOSITION NETWORK (PLANNED)
△ OPERATIONAL EVALUATION NETWORK (PLANNED)
● COLLOCATED SITE

FIGURE 2-4. Atmospheric deposition monitoring networks in the U.S. (From NAPAP, 1986)

TABLE 2-6. Summary of major acid deposition data bases for evaluation of regional acid deposition models.

	Meteorology				Vertical Profiles				Surface Concentration			
Reference	Spatial Domain and Resolution	Time Period	Temporal Resolution	Parameters	Spatial Domain and Resolution	Time Period	Temporal Resolution	Parameters	Location	Time Period	Temporal Resolution	Parameters
OSCAR Benkovitz et al., 1984	NE US	Apr 81	Hourly	Standard NWS surface	NE IN - NW OH, NJ, WV, OH DE, PA	8-9, 13-14, 16, 22-23, Apr 81	Variable	SO_2, NO, NO_2, O_3, HC, HNO_3, CN, b_{scat}, and aerosol H^+, NH_4, $SO_4^=$, NO_3^-, S, liq. H_2O content, temp, dew pt, relative hum, solar rad, UV, beta, cloud water pH and major ions	NE UA State Network sites	Apr 81	Hourly	SO_2, NO, NO_2, O_3
			12-hr	Standard NWS upper air							24-hr	TSP, $SO_4^=$, NO_3^-
	NE ID - NW OH, NJ, WV, PA	8-9 13-14, 16, 22-23	Continuous	Standard aircraft								
									Huntington,	8-9,13-14, 22-23	Variable	Aerosol $SO_4^=$, NO_3^- NH_4^+, strong acid with variable size discrimination; HNO_3, SO_2, NO, NO_x, O_3, PAN, H_2O_2, b_{scat}, dew pt.
									Long Island	10, 11-15, 22-26 Apr 81	Variable	NO_x, O_3; limited SO_2, HNO_3, Aerosol S
NEROS Possiel et al., 1982	NE US.	Aug 79, 14 Jul-15 Aug 80	Hourly	Standard NWS surface	NE US Regional Flights	3-5, 13-14, 15-17, 30-31 Aug 79	Variable	SO_2, O_3, NO_x, NO, CN, b_{scat}, UV solar, RH, dew pt, temp	NE US State Network sites	14 July-15 Aug 80	Hourly	SO_2, NO, NO_2, O_3,
			6-hr	Standard NWS upper air							24-hr	TSP, $SO_4^=$, NO_3^-
			Continuous	Standard aircraft	NE US Regional Flights	24,25,30 Jul; 1,2 5-9,10, 11 Aug 80	Variable	SO_2, SO_4, NO-NO_x, ANC, HC; Aerosol $SO_4^=$, NO_3^- (<3.5 um); temp, dew pt, turbulence	Columbus OH 4 SURE NECREMP	14 Jul-15 Aug 80 (Regional missions (1-2, 5-9 Aug 80)	Variable	SO_2, SO_4, NO-NO_x, O_3, b_{scat}, ANC, HC; aerosol $SO_4^=$, NO_3^- (<3.5 um); temp, dew pt., light levels
SURE Mueller et al., 1983	NE US	Jul 77-Nov 78	Hourly	Standard NWS susface	Spirals at 2 sites, several horizontals in NE US	3-7 days during Aug, Oct 77 Jan, Apr, Jul, Oct 78	Variable	SO_2, NO, NO_2, O_3, CN, b_{scat}, turbulence temp, dew pt, relative humidity, and aerosol mass, $SO_4^=$ and NO_3^- m size ranges	NE US 54 sites	19 months 1977-1978	Hourly 24-hr	SO_2, NO, NO_2, O_3, TSP, $SO_4^=$, NO_3^-
	NE US	Jun 77-Oct 78	12-hr	Standard NWS upper air								
	2 sites several tracts	3-7 days during Aug, Oct 77, Jan, Apr, Jul, Oct 78	continuous	Standard aircraft								

3 PREPARATION OF MODEL INPUT FILES

The evaluation of the ARM3 model requires adapting the Savannah River Laboratory and Oklahoma modelers' data base (Policastro et. al., 1986a) to the inputs required by ARM3. This data base was generously supplied on magnetic tape by Wastag (1988) and is described in Policastro et. al., 1986a,b. A considerable effort was devoted to developing appropriate model inputs to the ARM3.

OVERVIEW OF MODEL INPUTS REQUIRED

As a starting point it is appropriate to briefly review the data requirements of the ARM3 and identify the source of the required data for input. (The ARM3 formulation and input requirements are described in full by Morris and others, 1988.) An overall flow diagram of the ARM3 input and output files is presented in Figure 3-1. The ARM was designed to calculate the impacts from emission sources for one year by simulating each month separately by stepping through each month using time steps of about 1-hour. In the present application we applied the model for a short term application where hourly variable emission rates are important. The averaging times are also different requiring puff averaging over time periods other than an hour. Fortunately the ARM3 has provisions to handle these departures from the design problem.

Wind fields are generated by the ARM3 meteorological processor (METDWM) for the user-selected mesoscale modeling domain at several constant heights above ground level called "gama surfaces." The heights of these gama surfaces are specified by the user. (In the present study we used the default values given in Table 3-3.) Files with the suffix "DAT" (see Figure 3-1) are supplied as part of the ARM3 modeling package for the calendar year 1981 and the Rocky Mountain region. To model the time periods for this model evaluation we supplied our own surface and

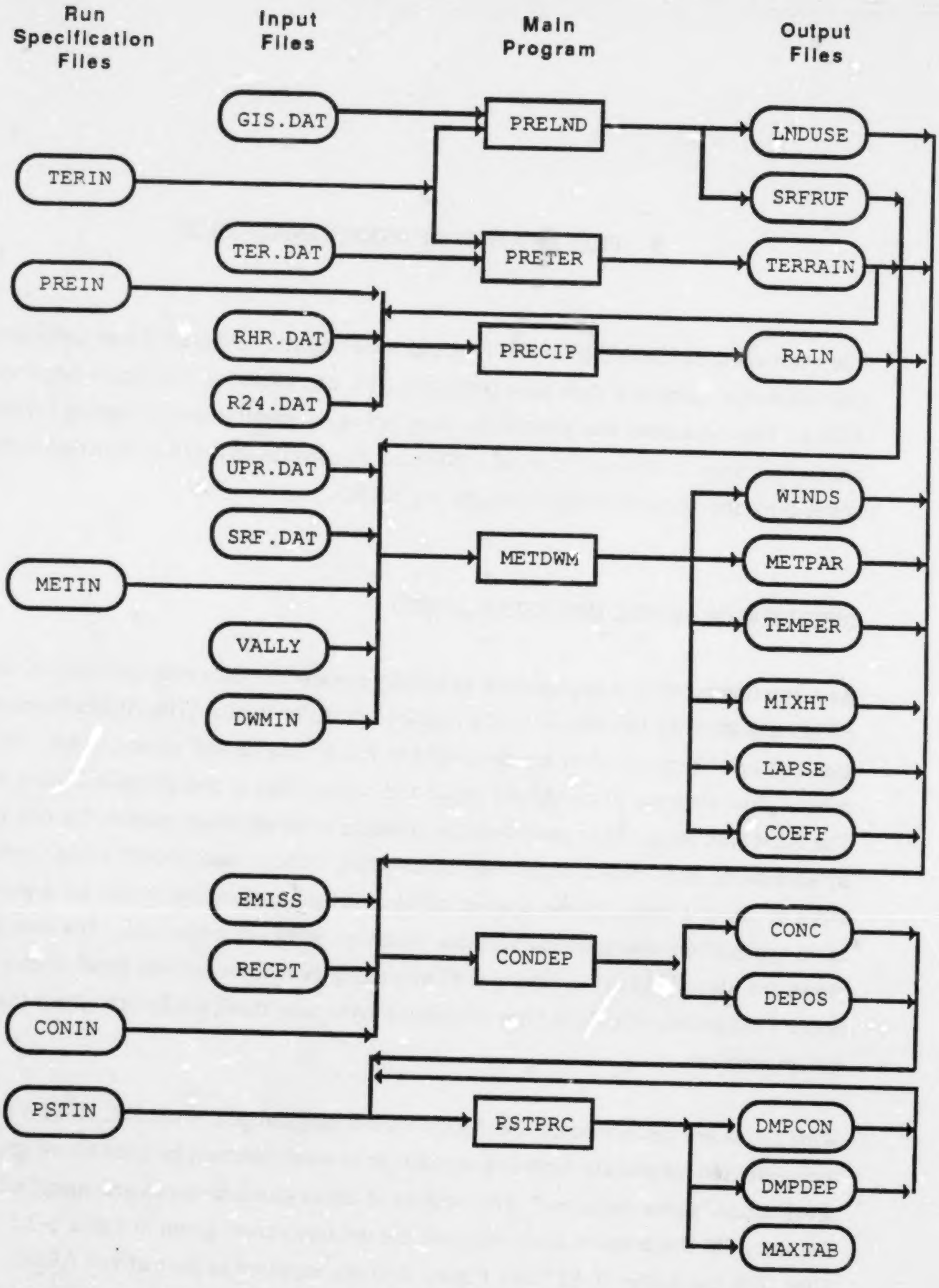
Run Specification Files
Input Files
Main Program
Output Files
GIS.DAT
PRELND
LNDUSE
TERIN
SRFRUF
TER.DAT
PRETER
TERRAIN
PREIN
RHR.DAT
PRECIP
RAIN
R24.DAT
UPR.DAT
WINDS
SRF.DAT
METDWM
METPAR
METIN
TEMPER
VALLY
MIXHT
DWMIN
LAPSE
COEFF
EMISS
CONC
RECPT
CONDEP
DEPOS
CONIN
PSTIN
PSTPRC
DMPCON
DMPDEP
MAXTAB

FIGURE 3-1. Flow diagram of ARM3 input and output files.

88121
88012
89024

upper-air meteorological data. The six main Fortran programs that make up the ARM3 modeling system are as follows:

PRELND, the land use preprocessor. This program uses data from the Geographic Information Systems (GIS) land cover data base and creates gridded fields of surface roughness and fractional land cover for the user-selected mesoscale modeling domain. The raw data file GIS.DAT covers the entire U.S. and was sufficient for the present modeling exercise.

PRETER, the terrain preprocessor. This program calculates the average terrain heights and terrain roughness values for the mesoscale modeling domain and grid spacing defined by the user from 20 files of 1 km terrain data that cover the master modeling domain. In these exercises we supplied 1 km gridded data from the USGS terrain data library for each of the two modeling regions.

PRECIP, the precipitation preprocessor. This program uses the 24-hour and hourly rainfall data supplied as part of the ARM3 to generate precipitation field on the user-specified grid and at the user-specified update interval. In this study the experiments were all assumed to be dry and an appropriate rain file with zeroes was created in order to exercise the ARM3.

METDWM, the mesoscale meteorological model. The model uses the data supplied by the preprocessors and the surface and upper-air meteorological observations to create several levels of gridded wind fields and gridded fields of mixing heights, temperatures, temperature lapse rates, stability, and other meteorological variables.

CONDEP. This program calculates hourly concentrations and deposition amounts from user-specified sources. The CONDEP program can be run for many different sources or source configurations using the same meteorological data from the preprocessors and the meteorological model.

PSTPRC, the postprocessor. This program creates tables of maximum concentrations and cumulative deposition amounts from the concentration and deposition data created by CONDEP. In the present study a heavily modified version of the PSTRC was developed to produce the appropriate predicted concentration averages to be consistent with the averaging times of the measured tracer data.

OVERVIEW OF THE TRACER EXPERIMENT DATA

Oklahoma Data Base

The Oklahoma (OK) data base was generated by the National Oceanic and Atmospheric Administration (NOAA) National Severe Storms Laboaratory (NSSL) and consists of two long-range tracer experiments: 8-9 July, 1980 and 11-12 July, 1980, using a perfluorcarbon (PMCH) tracer. Both experiments consisted of a 3-hr ground-level release of the PMCH tracer, which is neutrally buoyant and nondepositing, from Norman, Oklahoma with receptors located along an arc 100 km to the north of the release site. For the first experiment there was also an arc of receptors located 600 km downwind of the release site. The sampling interval for the tracer observations was either 45 minutes or 3 hours. For further details of the Oklahoma experiments, see Ferber and others (1981) or Policastro and others (1986a).

Savannah River Plant Data Base

The Savannah River Plant (SRP) data base consists of 15 experiments of Krypton-85 observations taken in the vicinity of the Savannah River Plant during the period of October 1976 to July, 1977. The Krypton-85 was released from two 62 meter stacks and measured at 15 sites around the plant located 28 to 144 km downwind of the stacks. The sampling interval for the measurements was 10 hours. For further details on the Savannah River Plant experiments, see Telegades and others (1980) or Policastro and others (1986a).

THE MODELING GRID SYSTEM

We adopted similiar modeling grid systems for the Oklahoma and Savannah River Plant regions as used by Argonne National Laboratory (ANL) in their evaluation of eight short-term long range transport models. The modeling domains for the Oklahoma and Savannah River Plant are presented in Figures 3-2 and 3-3. These figures also contains the locations of the surface and upper-air stations meteorological observation sites, the receptor locations, and the location of the source. The definition of the modeling domain used by the ARM3 landuse preprocessor (PRELND), mesoscale meteorological model (METDWM), and mesoscale air quality simulation model (CONDEP) for the OK and SRP applications are shown in Table 3-1. For the OK application the grid cell size was set at 20 km by 20 km resulting in an array of 51 by 41 cells. Whereas, the SRP application used a 33 by 56 array of 10 km by 10 km grid cells. The definition of these modeling domains and cell sizes was based in the following factors:

> The grid cell size and modeling domain size resembles that used in the ANL study Policastro et al. (1986a).
>
> Sufficient resolution exists to have approximately 1 station per grid cell on the 600 km arc.
>
> The number of grid cells does not require an excessive amount of computational resources.

OKLAHOMA DATA BASE

A total of 26 surface meteorological stations were available for the two Oklahoma tests (see Figure 3-2). Most sites had nearly complete data with the exception of Salem, Illinois which had incomplete surface data for the study period (July 7-12, 1980) and one other site which had no surface data (only upper air data). This left a total of 24 surface stations. This data was provided on a three hourly basis on a magnetic tape supplied by Wastag (1988). The data had to be reformatted and units converted to those needed by the meteorological processor METDWM, and to supply

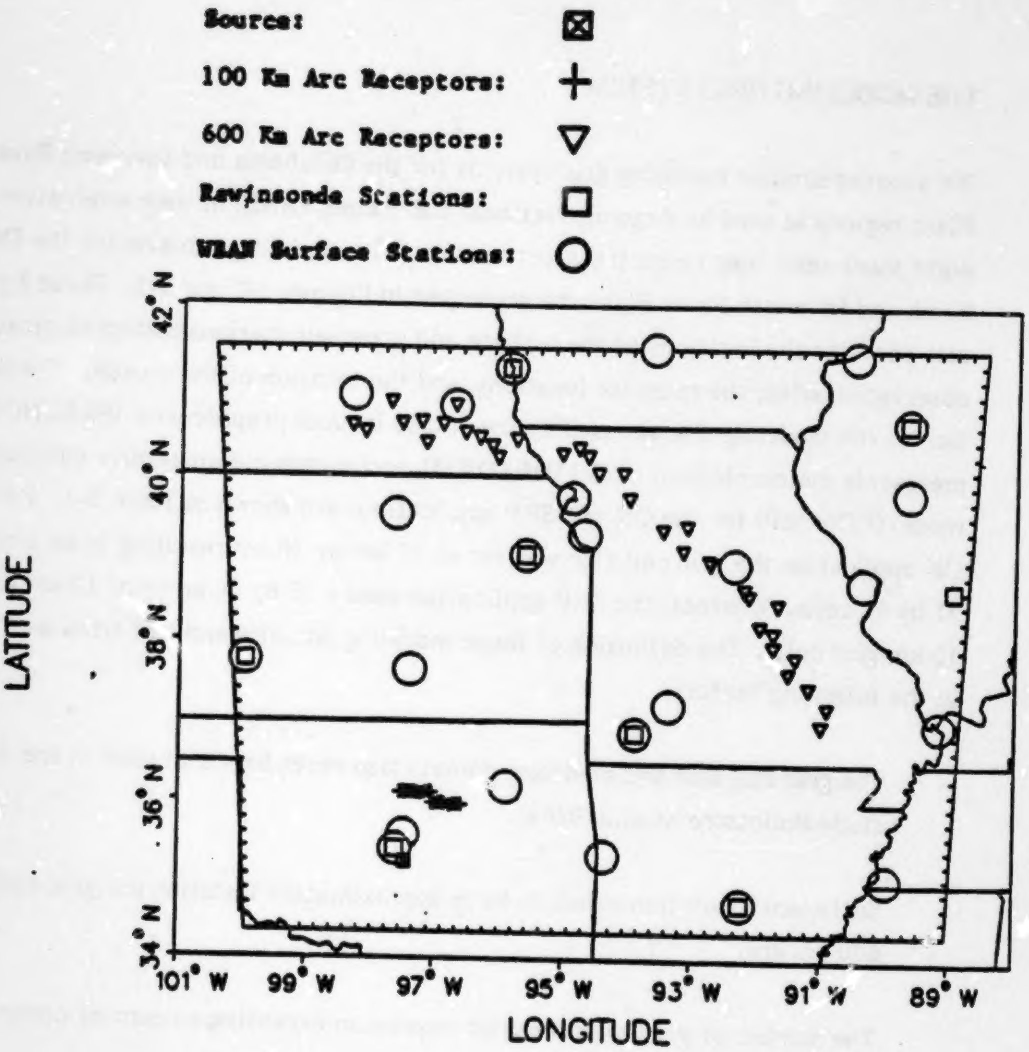
Source: ☒
100 Km Arc Receptors: +
600 Km Arc Receptors: ▽
Rawinsonde Stations: □
WBAN Surface Stations: ○
42° N
40° N
38° N
36° N
34° N
LATITUDE
101° W
99° W
97° W
95° W
93° W
91° W
89° W
LONGITUDE

FIGURE 3-2. Location of source, meteorological, and receptor sites for the Oklahoma data base. (Source: Policastro et al., 1986a)

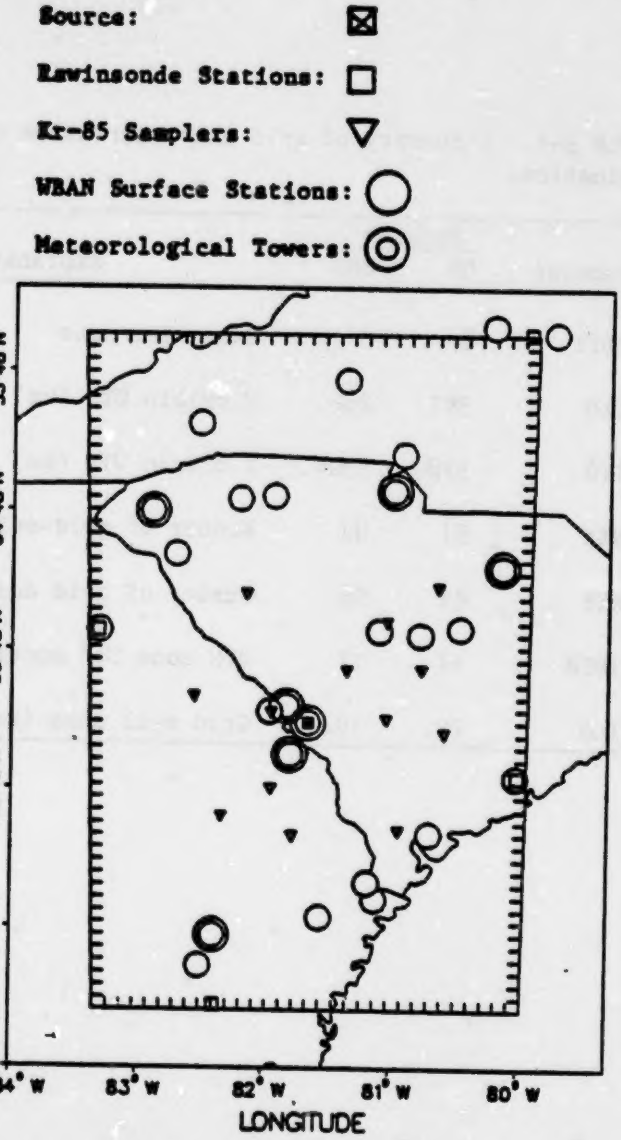
Source: ☒
Rawinsonde Stations: ☐
Kr-85 Samplers: ▽
WBAN Surface Stations: ○
Meteorological Towers: ◎
LATITUDE
35°48'N
34°48'N
33°48'N
32°48'N
31°48'N
30°48'N
84° W
83° W
82° W
81° W
80° W
LONGITUDE

FIGURE 3-3. Location of source, meteorological, and receptor sites for the Savannah River Plant base. (Source: Policastro et al., 1986a)

TABLE 3-1. A summary of grid characteristics used for the model evaluation.

Parameter	Setting		Explanation
	OK	SRP	
IBTZ	6	5	Base time zone
IXO	357.	268.	X origin UTM (km)
IYO	3789.	3324.	Y origin UTM (km)
NXX	51	33	Number of grid-cells in the X direction
NYY	41	56	Number of grid cells in the Y direction
IBZN	14	17	UTM zone for modeling domain
ICS	20.	10.	Grid cell size (km)

the necessary missing data flags. The file SRF.DAT was constructed for each for the two tests.

The rawinsonde data was available on tape for Oklahoma City, Oklahoma; Monett, Missouri; Topeka, Kansas; and Omaha, Nebraska. These observations were from July 8, 0000 GMT to July 12, 1200 GMT. The data included pressure, altitude (m above sea level), air temperature, dew point depressions, wind direction, and wind speed. Special rawinsonde observations were taken at Tinker Air Force Base about 20 km NNE of the release site, starting on the morning of July 8. These data (height, temperature, wind speed and direction) were also available for the evaluation study.

Generally at least six of the eight upper air stations employed in this model evaluation study are available during each 12-hour period experiment. Table 3-2 summarizes the availability and periods of record for the eight rawinsonde locations. The twice-daily data were reformatted to form the ARM3 UPR.DAT file for the METDWM preprocessor. This program converted units and inserted appropriate missing data flags.

SAVANNAH RIVER PLANT DATA BASE

Meteorological data for the krypton-85 Savannah River Plant experiments were collected and placed on magnetic tapes for the region within and surrounding the Savannah River Plant by the Savannah River Laboratory. The Savannah River Plant data base contains surface weather observations at stations between 120° to 60° longitude west and 50° to 20° latitude north. The weather observations were originally provided to SRL on magnetic tape from the NOAA National Climatic Center. About 60 surface weather stations report each hour in this general area. Figure 3-3 show the locations of surface stations within 200 km of the SRP source. A total of 26 surface weather stations located between 84° to 77° longitude west and 36° to 31° latitude north are included in the tape containing the SRP data base.

The standard NWS data (wind speed, direction, cloud cover, temperature and pressure) were available. The data were fairly complete for each of the 15 experiment periods with the exception of a single surface station which did not pass the minimum data requirements, leaving 25 surface sites.

TABLE 3-2. Availability and periods of record for the eight upper-air meteorological observation sites for the Oklahoma data base. (Source: Policastro et al., 1986a)

(1) SAL is Salem, IL — 03879
(2) UMN is Monett, MO — 03946
(3) LTR is Little Rock, AK — 13963
(4) OKC is Oklahoma City, OK — 13967
(5) DGC is Dodge City, KA — 13985
(6) TOP is Topeka, KA — 13996
(7) PEO is Peoria, IL — 14842
(8) OMA is Omaha, NB — 94918

DATE		YYJJJ	TIME	TIME	S A L	U M N	L T R	O K C	D G C	T O P	P E O	O M A	NO. TAKEN	SEQ. NO.
GMT	CST	GMT	GMT	CST										
7/07	7/07	80189	12	06	A	A	A	A	A	A	A	A	8	0
7/08	7/07	80190	00	18	A	A	A	A	A	A	A	A	8	1
7/08	7/08	80190	12	06	A	A	A	A	A	A	A	A	8	2
7/08	7/08	80190	18	12	[ ]	A	[ ]	[ ]	[ ]	A	[ ]	A	3	3
7/09	7/08	80191	00	18	[X]	A	A	[X]	A	A	A	A	7	4
7/09	7/09	80191	06	00	[ ]	A	[ ]	[ ]	[ ]	A	[ ]	A	3	5
7/09	7/09	80191	12	06	[X]	A	A	A	A	A	A	A	7	6
7/09	7/09	80191	18	12	[ ]	A	[ ]	[ ]	[ ]	A	[ ]	A	3	7
7/10	7/09	80192	00	18	[X]	A	A	A	A	A	A	A	7	8
7/10	7/10	80192	12	06	[X]	A	A	A	A	A	A	A	7	9
7/11	7/10	80193	00	18	[X]	A	A	A	A	A	A	A	7	10
7/11	7/11	80193	12	06	[X]	A	A	A	A	A	A	A	7	11
7/12	7/11	80194	00	18	[X]	A	A	A	A	[X]	A	A	6	12
7/12	7/12	80194	12	06	[X]	A	A	A	A	A	A	A	7	13
		TOTALS			3	14	11	11	11	13	11	14	88	

A = Available and included in the data base
[ ] = Not available
[X] = Not available, but filled in from nearest neighbor rws for some models

There are 88 available soundings out of 112 possible. With the "fill-ins" there ar still 88 soundings; the soundings at 06Z and 18Z cannot be used by any of the models.

Upper air soundings in the SRP data base were available from four stations at 12-hour intervals: Waycross and Athens, Georgia; Greenville and Charleston, South Carolina. The temperature wind, and height data for these sites was available on the magnetic tape containing the modeling meteorological data base. Missing data were treated by removal of layers where both wind speed/direction and temperature were missing. Linear interpolation was used to fill in layers where either only temperature, or only wind data was missing.

ARM SIMULATION OF THE OKLAHOMA AND SRP EXPERIMENTS

Some of the important inputs for the ARM3 meteorological model are listed in Table 3-3. In the operation of the ARM3 for the OK and SRP experiments we deviated slightly from the procedures used by ANL for evaluating the eight short-term long-range transport models (Policastro et al., 1986a). This was necessary because we wanted to operate the ARM3 in the same fashion as would be used by a western agency for the analysis of source impacts within the Rocky Mountain region. In particular, we used a three-hour update interval for the meteorological inputs and a puff release rate of three puffs per hour. For many of the models evaluated by ANL, hourly meteorological updates were used. A more rigorous comparison of the capabilities of the ARM3 may be obtained by using a more frequent meteorological and puff release frequency. However, we wished to evaluate not just the possible capabilities of the ARM3, but the performance of the ARM3 as it would be used in a Prevention of Significant Deterioration (PSD) permit application.

The periods of time that were modeled included the following test periods summarized in Table 3-4a and 3-4b for the two data bases. Each of the test cases presented in the tables was simulated from the day containing the start of the release to the end of the day when the last observation was made.

The settings for which the CONDEP model was operated with are summarized in Table 3-5. The model was operated with both the Irwin general formula dispersion coefficients and those with dispersion estimated from small scale terrain variation as outlined by MacCredy and others (1974). This latter method is only applied during stable conditions.

TABLE 3-3. A summary of options used in the meteorological preprocessor during the model performance evaluation exercise (METIN).

Parameter	Setting	Explanation
IMC	3	Meteorological update frequency
IHH	1	Constant height of top boundary above terrain
HH	3000.	Height of top boundary
NGAMA	6	Number layer interfaces
CELLZB	0 20 180 420 980 1820 2980	Heights of vertical layer interfaces (m agl)
NVALE	0	Number of valleys with sources
LDOM	.true.	Logical flag for using master modeling data (.true. = not used)

TABLE. 3-4a. A summary of the experiment times and dates modeled for the Oklahoma evaluation study.

Case ID	dd/mm/yy	Time (LST-beginning)
20-a	08/07/80	2100
20-b	08/07/80	2145
20-c	08/07/80	2230
20-d	08/07/80	2315
20-e	09/07/80	0.0
20-f	09/07/80	45
20-g	09/07/80	130
30-a	09/07/80	800
30-b	09/07/80	1100
30-c	09/07/80	1400
30-d	09/07/80	1700
30-e	09/07/80	2000
30-f	09/07/80	2300
40-a	11/07/80	2200
40-b	11/07/80	2245
40-c	11/07/80	2330
40-d	12/07/80	15
40-e	12/07/80	100
40-f	12/07/80	145
40-g	12/07/80	230

TABLE 3-4b. A summary of the experiment times and dates modeled for the Savannah River Plant evaluation study.

Case ID	dd/mm/yy	Time (LST-beginning)
1-a	05/10/76	2200
2-a	14/10/76	2100
2-b	15/10/76	1300
2-c	15/10/76	2200
3-a	29/10/76	0900
3-b	29/10/76	2100
4-a	18/11/76	1000
4-b	18/11/76	2200
4-c	19/11/76	1000
4-d	19/11/76	2200
5-a	02/02/77	1000
5-b	02/02/77	2100
5-c	03/02/77	1000
5-d	03/02/77	2100
6-a	16/02/77	2200
6-b	17/02/77	1000
6-c	17/02/77	2200
6-d	17/02/77	1000
6-e	18/02/77	2200
7-a	22/02/77	1000
7-b	22/02/77	2200
8-a	05/04/77	2100
8-b	06/04/77	1000
8-c	06/04/77	2100
8-d	07/04/77	1000
8-e	07/04/77	2100
8-f	08/04/77	1000

continued

TABLE 3-4b. continued

Case ID	dd/mm/yy	Time (LST-beginning)
8-g	08/04/77	2200
9-a	11/04/77	0900
9-b	11/04/77	2100
9-c	12/04/77	1000
9-d	12/04/77	2100
9-e	13/04/77	0900
9-f	13/04/77	2100
9-g	14/04/77	0900
9-h	14/04/77	2200
9-i	15/04/77	0900
9-j	15/04/77	2100
10-a	17/04/77	2200
10-b	18/04/77	0900
10-c	18/04/77	2100
10-d	19/04/77	0900
10-e	19/04/77	2200
10-f	20/04/77	0900
10-g	20/04/77	2200
10-h	21/04/77	0900
10-i	21/04/77	2100
10-j	22/04/77	0900
11-a	27/04/77	8800
11-b	27/04/77	2100
11-c	28/04/77	0900
11-d	28/04/77	2000
12-a	11/07/77	0900
12-b	11/07/77	1600
13-a	15/07/77	0900
13-b	15/07/77	2100

continued

TABLE 3-4b. concluded

Case ID	dd/mm/yy	Time (LST-beginning)
14-a	18/07/77	0900
14-b	18/07/77	2000
14-c	19/07/77	0800
14-d	19/07/77	2100
14-e	20/07/77	0800
15-a	25/07/77	0800
15-b	25/07/77	2100
15-c	26/07/77	0800
15-d	26/07/77	2000

TABLE 3-5. A summary of model options utilized in the model performance evaluation exercise (CONIN).

Parameter	Setting	Explanation
IPRR	3	Three puffs released per hour
LUFORM	.false.	Use vertical Gaussian distribution near the source
WOFF	.true.	Use empirical plume height corrections for vertical transport of the puff
METHOD	1	Irwin's general formula II dispersion coefficients
LVALTR	.false.	Do not use nocturnal source valley treatment
IUPDT	3	Meteorological update frequency (hours)
NPLT	1	Number of pollutants
CT(I)	defaults	Plume height adjustment coefficients
ICHEM	5	Specifies inert chemical transformation model
IO3	2	Input values (all zeros)

Since the model exercises occurred in relatively smooth terrain this option did not seem appropriate. As a result only the Irwin general formula dispersion coefficients are reported. The model was operated with three puff releases per hour and the near source spread in the vertical was assumed to be Gaussian rather than uniform. The surface deposition velocity was set equal to zero and the empirical plume height adjustments were used. The emissions input data units were converted to be compatible with ARM3 requirements.

POSTPROCESSING OF THE ARM3 PREDICTIONS

In the present model evaluation exercise we did not utilize the ARM3 concentration post processor PSTPRC in order summarize the predicted concentrations at the receptor points and over the receptor grid. The main reason is the irregular averaging periods for the two experiments ranging in length from 3/4 to 15 hours. Starting and stopping time of the observations were obtained from the file of observations and predictions provided by Wastag (1988) and summarized by Policastro and others (1986b).

The CONC output files from CONDEP were produced in the formatted fashion so as to facilitate analysis. The hourly data at the receptor grids and receptor sites were averaged over the specified collection period at each receptor. Grids were averaged assuming the maximum possible averaging period of the experiment case, so no attempt was made to modify grid averages by a shorter reception collector period. The average predicted receptor concentrations are the focus of the present model evaluation. Gridded concentration fields exhibited large concentration gradients which could only provide the basis for qualitative checks about matters such as the plume centerline.

4 EVALUATION OF THE ARM3

The evaluation of the ARM3 is accomplished in several tasks:

1. A diagnostic evaluation in which each of the major components of the ARM3 are evaluated separately. This was performed as part of the development of the ARM3 and is reported by Morris et al. (1987).

2. A comparison of the ARM3 predictions with those of two EPA-recommended air quality simulation models under a set of simplified conditions. The ARM3 predictions were compared with those obtained by MPTER(URBAN) and ISCST(RURAL). This preliminary evaluation of the ARM3 is described in Appendix B.

3. A separate evaluation of the Diagnostic Wind Model component of ARM3, which also examined the data requirements of the wind model. A brief description of this evaluation is given in Appendix C, while a more complete evaluation of the DWM is reported by Kessler and Douglas (1988).

4. An evaluation of the complete ARM3 modeling system against observed tracer data using data bases from Oklahoma and Savannah River Plant. This evaluation, reported in this section, also includes a comparison of model performance with up to seven other mesoscale air quality simulation models.

In the following paragraphs we discuss the ability of the ARM3 to reproduce observed tracer concentrations for the OK and SRP experiments. In particular we evaluate the ARM3's ability to replicate all of the tracer observations (matched by time and location), the very highest tracer observations (unmatched by time or location), and the maximum observed tracer concentration for each temporal averaging period of the OK and SRP data sets (matched by time but not location) A valuable component of this model evaluation study is the work performed by Argonne National Laboratory (ANL) which evaluated 8 long-range short-term air quality simulation models using the same data bases (Policastro et al., 1986a,b). Thus, in the following model evaluation of the ARM3 the evaluation results of other long-range transport models are also presented. With this "baseline" of model performance measures, the relative predictive ability of the ARM3 can be assessed with respect to the other models. The models are then ranked for the different data sets to determine whether ARM3 exhibits better or worse skill at predicting observations then the other air quality simulation models. Finally, an overall ranking of the mesoscale transport models is presented.

The model developers and the eight long-range transport models evaluated by the ANL group using the OK and SRP data bases are as follows:

MESOPUFF-I, Environmental Research and Technology (Benkley and Bass, 1979ab)

MESOPLUME, Environmental Research and Technology (Benkley and Bass, 1979c)

MSPUFF, North Dakota Department of Health (Schock and Weber, 1982, 1984)

MESOPUFF-II, Environmental Research and Technology (Scire et al., 1984ab, Scire and Lurmann, 1983)

MTDDIS, Rockwell International Inc. (Wang and Waldron, 1980)

ARRPA, Tennessee Valley Authority (Mueller and Valente, 1983; Mueller et al., 1983)

RADM, Dames and Moore (Austin, Bealer, and Goodin, 1981)

RTM-II, Systems Applications, Inc. (Yocke, Morris, and Liu, 1982)

Model predictions for all of these models, except MTTDIS, were obtained from ANL. The ARRPA model was only exercised for the Oklahoma data set. this resulted in a comparison of the performance of ARM3 against seven other models for the OK data set and six other models for the SRP data set.

MODEL PERFORMANCE FOR ALL DATA

The OK and SRP data sets resulted in 380 and 627, respectively, predicted and observed pairs from which statistical performance measures could be calculated for the long-range transport models. Note that in the following discussion zero concentration pairs were included when calculating statistical performance measures. The inclusion of zero concentration pairs in the statistical analysis was done for the following reasons: (1) to assure that the same sample size is obtained for all of the models; and (2) to include cases when both the observations and the model indicate that the plume misses the receptor. Because we will compare model performance statistics produced by different models, zero concentration pairs must be included to obtain the same number of predicted and observed pairs for all models. The exclusion of zero concentration pairs would result in different sample sites for each model, in which case model performance statistics could not be compared. Note that inclusion of zero concentration pairs in the analysis will not affect the relative ranking of an individual model's ability to predict the tracer observations. The statistical performance measures reported here consist of the following (see Appendix A for mathematical description):

Average
Bias with 95 percent confidence interval
Percent bias is of the average observation
Average absolute (gross) error
Percent absolute error is of the average
Correlation coefficient with 95 percent confidence interval
The percent of the predictions and observations that are within a factor of two.

Briefly, the bias gives an indication of how well the model predictions, on average, match the observations. A bias near zero would indicate that the model is underpredicting the observations as frequently as it over predicts. Since the bias in units dependent, we also report the bias as a percentage of the average observation. A zero bias does not necessarily indicate good model performance. For example, a model can predict the exact opposite of the observations and may have a zero bias because the overpredictions are cancelled by the underpredictions. Thus, we also report the average absolute (gross) error. A zero absolute error would indicate perfect model performance. The absolute error is also reported in terms of a percentage of the average observation.

In order to determine how will the model predictions follow the variability in the observations we report the correlation coefficient. A correlation coefficient of 1 indicates the model is exactly replicating the trends of the observations, whereas, a correlation coefficient of -1 indicates that the model is predicting the opposite trends of the observations. A model can have a high correlation coefficient and still not replicate the observations well. But this occurence would be evident in the bias and absolute error statistical measures.

The summary statistical performance measures for the OK and SRP data sets for the air quality simulation models are listed in Tables 4-1 and 4-2. As discussed in the modeling protocol (Appendix A), sometimes it is useful to examine qualitative model performance measures such as scatter plots and time series of predictions and observations and spatial maps of predictions with inserted observations. However, for these tracer tests, we found these qualitative measures of limited usefulness for interpreting model performance. The tracer data tend to be hit or miss events; thus time series plots exhibit a ragged series of sharp peaks and valleys and scatter plots tend to have most data points along the predicted or observed zero axis. However, as part of the Systems Applications Statistical Evaluation Performance Software (SPES) scatter plots of predictions and observations and additional statistical model performance measures (see Appendix A) for the OK and SRP data sets are listed in, respectively, Appendicies D and E. In addition, a complete listing of the predictions and observations for all models and all of the experiments in the OK and SRP data bases are listed in Appendicies F and G, respectively.

TABLE 4-1. Summary statistical model performance measures for the Oklahoma data base (N=380), concentrations in parts per 10**15.[a,b]

Model	Average	Bias and 95% Interval	Percent Bias	Average Absolute Error	Percent Absolute Error	Correlation Coefficient (95% Interval)	Percent within a Factor of 2
Observed	143.5						
MESOPUFF-2	195.3	-51.8±70.7	36%	313.6	219%	-0.059 (-.159:.042)	51
MESOPLUME	252.2	-108.7±96.5	76%	221.2	154%	0.593 (.523:.654)	47
MSPUFF	469.0	-326.0±186.0	227%	428.8	299%	0.759 (.713:.798)	42
RTM-II	139.1	4.4±55.7	3%	213.0	148%	0.179 (.080:.275)	47
RADM	508.2	-364.8±147.7	254%	609.0	424%	-0.027 (-.127:.074)	42
ARRPA	257.1	-113.6±97.0	79%	350.4	244%	0.009 (.092:.110)	40
MESOPUFF-I	211.8	-68.4±77.3	48%	171.2	119%	0.694 (.638:.743)	46
ARM3	229.2	-85.7±87.8	60%	180.7	126%	0.718 (.665:.763)	50

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[a] Zero predicted/observed concentration pairs are included.

[b] A complete set of model performance statistics is given in Appendix D.

TABLE 4-2. Summary model performance statistics for the Savannah River Plant (SRP) data base concentrations in p Ci/m^3 (N = 627).[a,b]

Model	Average	Bias and 95% Interval	Percent Bias	Average Absolute Error	Percent Absolute Error	Correlation Coefficient (95% Interval)	Percent within a Factor of 2
Observed	35.1						
MESOPUFF-2	39.9	-4.9±16.2	14%	64.3	183%	0.031 (-.048:.109)	49
MESOPLUME	41.4	-6.3±18.9	18%	65.5	187%	0.082 (.004:.160)	54
MSPUFF	40.6	-5.5±19.2	16%	69.6	198%	0.012 (-.066:.090)	48
RTM-II	37.5	-2.4±15.2	7%	58.0	165%	0.132 (-.054:.208)	51
RADM	135.1	-100.1±123.8	285%	151.9	433%	0.264 (.189:.335)	54
MESOPUFF-I	41.2	-6.2±21.4	18%	65.8	187%	0.096 (.018:.173)	54
ARM3	37.4	-2.3±15.0	7%	60.0	171%	0.101 (.022:.178)	52

[a] Zero predicted/observed concentration pairs are included.
[b] A complete set of model performance statistics is included in Appendix E.

Oklahoma Data Set (Matched by Time and Location)

For the OK data set (Table 4-1), the model bias for the seven models ranges from 3 to 254 percent, while the gross error ranges from 107 to 119 percent. The RTM-II has the lowest bias, but two other models (MESOPUFF-I and ARM3) have lower absolute error which indicates that the low RTM-II bias may be due to the cancellation of under- and overpredictions.

Both the MSPUFF and RADM appear to greatly overpredict with the bias in excess of 200 percent and the absolute error at 299 and 424 percent, respectively. The MSPUFF has the highest correlation coefficient (0.759), which indicates that, even with its tendency to grossly overpredict the observations, it shows some skill in following the trends of the observations.

When examining all model performance statistical measures for the OK data base matched by time and location the ARM3 and MESOPUFF-I exhibit the most skill in replicating the observations with fairly low values for bias (48 and 60 percent) and absolute error (119 and 126 percent), and high correlation coefficients (0.694 and 0.718). Some skill is predicting the observations is also indicated by the MESOPLUME and RTM-II models. Both models have absolute error of about 150 percent, where RTM-II has the lowest bias (3 percent) and MESOPLUME a high correlation coefficient (0.593). Less skill at reproducing the observations is seen with the MESOPUFF-II, and ARRPA models which have bias of less than 100 percent, absolute average errors of less than 250 percent, and very low correlation coefficients. Finally, the least skill in predicting the observations is given by the RADM and MSPUFF; bias exceeds 200 percent and absolute errors exceed 250 percent.

Savannah River Plant Data Set (Matched by Time and Location)

Except for the RADM model, which tends to overpredict for the SRP data set (with a bias of 285 percent and an absolute error of 433 percent), all of the other models have similiar values for bias, absolute error, and correlation coefficients that range from, respectively, 7 to 18 percent, 154 to 198 percent, and 0.031 to 0.132 (Table 4-2). The ARM3 and the RTM-II have the lowest bias (7 percent) and the lowest absolute error (171 and 165 percent). The RTM-II and ARM3 also have the second and third highest correlation coefficients (0.132 and 0.101) of the models. The highest correlation coefficient is predicted by the RADM model (0.264).

The other four models (MESOPUFF-II, MESOPLUME, MSPUFF, and MESOPUFF-I) exhibit similiar model performance, with bias ranging from 14 to 18 percent, absolute error ranging from 183 to 198 percent, and correlation coefficients less than 0.1 but greater than zero.

MODEL PERFORMANCE FOR THE HIGHEST OBSERVATIONS

An important attribute of an air quality simulation model intended to be used for regulatory decision making is to accurately reproduce the peak observations. We examine the ability of the ARM3 and the other air quality models to predict the peak observations by comparing the highest 25 observations and predictions for the OK and SRP data sets (unmatched by time or location). We also examine the ability of the mesoscale air quality simulation models to reproduce the maximum observations for each averaging period in the OK and SRP data sets (matched by time but not location).

Data Unmatched by Time or Location

Oklahoma Data

Table 4-3 lists the highest 25 (unmatched) predicted and observed concentrations for the OK data set. The tendency for the MSPUFF and RADM models to overpredict the observations is clearly evident, where they overpredict the average of the 25 highest observations by over a factor of three. One model, the RTM-II, underpredicts the average of the 25 highest observations by 32 percent. Of the remaining models, the average of the 25 highest concentrations are overpredicted by 23 percent for MESOPUFF-II, 45 percent for MESOPUFF-I, 55 percent for ARM3, 76 percent for ARRPA, and 79 percent for MESOPLUME. Although MESOPUFF-II is the most accurate model in predicting the average of the 25 highest observations, it underpredicts the five highest concentrations by 9 percent. All of the other models, except the

TABLE 4-3. Highest 25 predicted and observed tracer concentrations (parts per 10^{15}) and the average of the 25 highest concentrations for the Oklahoma data set.

Rank	OBS	PUFF2	PLUME	MSPUF	RTM2	RADM	ARRPA	PUFF1	ARM3
1	5897.	4069.	10813.	20281.	1566.	12880.	10242.	4646.	9285.
2	4667.	4022.	6649.	16899.	1544.	12167.	8115.	4625.	6879.
3	3997.	3642.	5136.	14808.	1536.	11241.	7598.	4200.	5740.
4	2837.	3447.	5031.	13179.	1530.	9433.	4507.	4075.	4664.
5	2807.	3275.	4847.	12668.	1451.	8027.	4390.	4007.	4188.
6	2737.	3244.	4787.	11334.	1420.	7711.	4037.	3881.	3723.
7	2727.	2891.	4341.	11176.	1402.	7607.	3927.	3631.	3488.
8	2167.	2882.	4152.	10297.	1390.	5999.	3690.	3623.	3468.
9	2097.	2734.	4115.	6554.	1383.	5954.	3639.	2940.	2740.
10	1647.	2495.	3976.	5702.	1374.	5460.	3515.	2893.	2434.
11	1297.	2129.	3539.	4546.	1359.	5261.	3207.	2758.	2326.
12	1277.	2079.	2860.	3726.	1348.	5160.	2960.	2738.	2320.
13	1257.	1938.	2793.	2937.	1324.	4705.	2616.	2706.	2311.
14	1107.	1832.	2729.	2854.	1309.	4604.	2449.	2534.	2232.
15	1007.	1825.	2454.	2590.	1187.	4581.	2301.	2362.	2016.
16	997.	1682.	2408.	2453.	1181.	4563.	1502.	1892.	1676.
17	977.	1640.	1783.	2315.	1174.	4502.	1463.	1629.	1591.
18	917.	1640.	1452.	2114.	1170.	4502.	1346.	1555.	1550.
19	897.	1578.	1412.	1997.	1165.	4321.	1306.	1514.	1471.
20	817.	1436.	1355.	1988.	1157.	3514.	1234.	1498.	1217.
21	757.	1299.	923.	1953.	823.	3419.	1230.	1376.	1193.
22	647.	1161.	851.	1858.	812.	3418.	1209.	1338.	1089.
23	624.	961.	816.	1564.	765.	2878.	1127.	1189.	1011.
24	557.	936.	809.	1515.	762.	2752.	999.	1085.	855.
25	527.	926.	757.	1367.	727.	2691.	980.	746.	722.
avg	1810.	2230.	3231.	6347.	1234.	5894.	3184.	2618.	2807.

RTM-II, overpredict the five highest observations by 7 percent (MESOPUFF-I) to 285 percent (MSPUFF). The ARM3 overpredicts the five highest obervations by 52 percent, and the RTM-II underpredicts the five highest concentrations by 32 percent.

Savannah River Plant Data

The 25 highest predictions and observations for the SRP data set are listed in Table 4-4. The MESOPUFF-II, RTM-II, and ARM3 all predict the average of the 25 highest observations to within less than 20 percent (8, 4, and 2 percent, respectively). Except for the RADM model, which over predicts the average of the 25 highest observations by almost a factor of 5, the other three models overpredict this average by from 33 to 44 percent. An examination of the five highest concentrations revals that the MESOPUFF-II and RTM-II are the most accurate (12 percent overprediction and 9 percent underprediction) followed by the ARM3 (15 percent overprediction), MESOPLUME (38 percent overprediction), MSPUFF (48 percent overprediction), MESOPUFF-I (58 percent overprediction), and RADM (631 percent overprediction).

Data Matched By Time But Not Location

Oklahoma Data Set

Table 4-5 list the maximum predicted and observed concentrations for each of the 21 sampling intervals in the OK data set. Also listed in Table 4-10 is the average of the maximum values from each experiement and the correlation coefficient between the predicted and observed maximum values. The MESOPUFF-II, MESOPUFF-I, and ARM3 are the only models that predict the maximum observation for each sampling interval within a factor of two. While the MESOPLUME, RTM-II, and ARRPA are almost within a factor of two, where RTM-II is the only model that underpredicts the average of the maximum observed tracer concentration from each sampling interval. The RADM and MSPUFF models over predict these maximum observed values by over a factor of 3 and 5, respectively. The ARM3, MESOPLUME, and MESOPUFF-I show the most skill at predicting the observed variability in the maximum values from the different sampling interval with correlation coefficients of, respec-

TABLE 4-4. Highest 25 predicted and observed tracer concentrations (pCi/m^3) and the average of the 25 highest concentrations for the Savannah River Plant data set.

Rank	OBS	PUFF2	PLUME	MSPUF	RTM2	RADM	PUFF1	ARM3
1	2260.	2360.	3299.	3582.	2154.	46384.	5309.	2000.
2	1558.	2065.	2477.	2347.	1756.	4531.	2838.	1341.
3	1509.	1833.	2295.	2327.	1402.	2546.	1603.	1326.
4	1436.	1453.	1603.	2171.	1045.	2381.	1454.	1102.
5	1152.	1184.	1253.	1282.	808.	2077.	1322.	998.
6	1040.	797.	1208.	1199.	766.	1891.	1128.	935.
7	781.	767.	1090.	1038.	711.	1503.	1106.	881.
8	661.	741.	924.	826.	651.	1406.	1013.	652.
9	660.	615.	867.	778.	621.	1295.	787.	618.
10	616.	545.	853.	606.	613.	1269.	778.	569.
11	418.	513.	793.	582.	593.	1195.	752.	529.
12	411.	459.	718.	549.	568.	1169.	607.	498.
13	366.	457.	645.	505.	538.	1132.	557.	462.
14	360.	444.	521.	491.	508.	1120.	510.	458.
15	340.	431.	505.	466.	475.	1119.	479.	430.
16	331.	376.	485.	406.	463.	834.	427.	421.
17	292.	373.	448.	402.	451.	716.	340.	382.
18	280.	330.	389.	350.	371.	566.	324.	372.
19	264.	313.	388.	264.	355.	548.	291.	371.
20	244.	297.	371.	263.	338.	472.	282.	365.
21	242.	256.	340.	213.	312.	432.	278.	353.
22	239.	240.	321.	213.	306.	414.	262.	350.
23	227.	237.	321.	210.	295.	390.	250.	333.
24	223.	222.	312.	201.	292.	377.	249.	310.
25	184.	203.	310.	198.	280.	329.	210.	302.
avg	644.	700.	909.	859.	667.	3044.	926.	654.

TABLE 4-5. Highest predicted and observed tracer concentrations (parts per 10^{15}) for each sampling interval plus the average of the highest concentrations and correlation coefficient of the Oklahoma data set (matched by time but not location).

S. NO.	OBS	PUFF2	PLUME	MSPUF	RTM2	RADM	ARRPA	PUFF1	ARM3
1	3.	11.	5136.	5702.	0.	0.	0.	2362.	0.
2	1297.	1938.	5031.	12668.	389.	3418.	3515.	3881.	2434.
3	5897.	3275.	6649.	16899.	663.	7711.	3927.	4646.	6879.
4	2837.	4069.	10813.	20281.	823.	12880.	4507.	4625.	9285.
5	2167.	3642.	816.	11176.	1566.	8027.	10242.	4075.	4664.
6	40.	2891.	272.	3726.	1402.	5999.	3639.	1498.	1591.
7	3.	2495.	0.	1.	1187.	4502.	420.	128.	855.
8	1277.	0.	0.	492.	0.	0.	10.	3.	97.
9	817.	0.	659.	813.	0.	0.	2449.	486.	511.
10	347.	159.	509.	271.	2.	0.	889.	746.	353.
11	63.	118.	170.	90.	3.	286.	192.	269.	214.
12	3.	39.	57.	30.	1.	95.	64.	90.	52.
13	0.	13.	19.	10.	0.	32.	21.	30.	21.
14	7.	1.	585.	180.	0.	0.	0.	304.	233.
15	297.	299.	555.	1367.	128.	408.	396.	397.	663.
16	357.	619.	704.	1988.	236.	1157.	493.	453.	679.
17	233.	961.	1355.	2453.	323.	2249.	612.	497.	722.
18	96.	936.	33.	2315.	217.	2009.	1306.	355.	1550.
19	46.	734.	11.	929.	160.	1747.	435.	153.	348.
20	21.	715.	0.	157.	120.	1393.	69.	14.	484.
21	7.	542.	0.	0.	100.	780.	0.	0.	0.
avg	753.	1117.	1589.	3883.	349.	2509.	1580.	1191.	1506.
corr. coef.		.642	.673	.818	.354	.669	.580	.787	.838

tively, 0.838, 0.818, and 0.787. The other models show less skill in replicating this observed temporal variability from different time periods with RTM-II exhibiting the lowest skill with a correlation coefficient of 0.354.

Savannah River Plant Data Set

Maximum predicted and observed concentrations for each of the SRP sampling time intervals, their averages, and correlation coefficients are listed in Table 4-6. All models, except for RADM, predict the average of the maximum observation for each time interval to within 30 percent. RADM overpredicted these maximum observations by almost a factor of 5. The MESOPUFF-II, MSPUFF, RTM-II, and ARM3 all predicted the average of the observed maximum tracer concentrations for each interval to within about 10 percent, however MESOPUFF-II had a negative correlation coefficient indicating it had less skill than the other models in predicting the temporal variability in the maximum observations. The ARM3 overpredicted these maximum observations by 11 percent and illustrated a little skill in replicating the temporal variability with a correlation coefficient of 0.084.

RANKING OF MODEL PERFORMANCE

Due to the wide range of statistical measures, the relative ranking of model performance is somewhat subjective and based on how one weights the merits of individual statistical performance measures. Ranking models ability to predict tracer data is particularly difficult because the natural variability of the atmosphere and the inability of a coarse network of meteorological observations to capture this variability. A case can be made for poor performance for all of the models discussed here (McNider, 1987). However, the purpose of this model ranking is to use the statistical performance measures presented to determine whether the ARM3 can predict the observed tracer concentrations as good as, better, or worse than the existing mesoscale air quality simulation models. Since the models behaved differently for the OK and SRP data sets, and the models also varied in their ability to reproduce the maximum observations versus all observations, the models are ranked separately for these categories.

TABLE 4-6. Highest predicted and observed tracer concentrations (pCi/m3) for each sampling interval plus the average of the highest concentrations and the correlation coefficient for the Savannah River Plant data set (matched by time but not location).

S.NO.	OBS	PUFF2	PLUME	MSPUF	RTM2	RADM	PUFF1	ARM3
1	660.	237.	389.	505.	1756.	4531.	510.	881.
2	32.	615.	924.	263.	338.	0.	1322.	273.
3	33.	457.	310.	176.	231.	0.	1128.	350.
4	175.	155.	0.	0.	766.	0.	0.	0.
5	331.	0.	246.	213.	54.	0.	147.	76.
6	227.	25.	71.	88.	57.	0.	64.	26.
7	10.	0.	0.	0.	1.	0.	0.	0.
8	64.	49.	1.	140.	200.	135.	119.	122.
9	239.	297.	193.	170.	110.	377.	146.	151.
10	11.	0.	0.	0.	0.	0.	0.	0.
11	102.	158.	39.	0.	261.	286.	9.	146.
12	13.	17.	100.	0.	126.	11.	27.	38.
13	418.	20.	853.	0.	593.	1195.	1454.	652.
14	82.	1.	0.	0.	0.	390.	0.	0.
15	36.	0.	521.	0.	651.	0.	427.	0.
16	56.	28.	129.	0.	82.	1120.	58.	170.
17	244.	9.	22.	3.	12.	147.	13.	18.
18	242.	194.	1090.	2171.	613.	432.	1603.	1326.
19	108.	313.	34.	491.	78.	282.	14.	97.
20	661.	44.	7.	0.	26.	2077.	5.	421.
21	8.	0.	0.	0.	0.	0.	0.	0.
22	2.	0.	0.	0.	6.	0.	0.	0.
23	616.	8.	0.	0.	1.	0.	0.	1.
24	157.	119.	0.	0.	24.	1132.	4.	257.
25	50.	101.	43.	5.	19.	191.	39.	83.
26	147.	15.	0.	0.	0.	0.	0.	3.
27	53.	240.	0.	16.	0.	227.	0.	0.
28	52.	0.	0.	0.	0.	0.	0.	0.
29	280.	2360.	0.	0.	475.	304.	11.	458.
30	78.	767.	2477.	0.	538.	1503.	210.	618.
31	16.	109.	793.	0.	371.	264.	262.	382.
32	3.	1833.	27.	0.	1402.	246.	340.	462.
33	139.	137.	1253.	0.	451.	244.	2838.	998.
34	19.	89.	175.	71.	131.	156.	202.	128.
35	2.	58.	0.	48.	5.	5.	4.	14.

TABLE 4-6. Concluded.

S.NO.	OBS	PUFF2	PLUME	MSPUF	RTM2	RADM	PUFF1	ARM3
36	340.	50.	0.	1282.	7.	179.	3.	293.
37	143.	27.	321.	12.	227.	2546.	607.	353.
38	27.	44.	109.	13.	88.	1295.	14.	214.
39	1040.	146.	0.	0.	66.	46384.	0.	0.
40	69.	459.	371.	191.	127.	1269.	116.	498.
41	2.	330.	0.	210.	79.	77.	0.	0.
42	264.	545.	3299.	778.	1045.	1119.	1013.	935.
43	9.	741.	116.	1038.	109.	117.	162.	430.
44	1436.	198.	142.	3582.	2154.	320.	7.	569.
45	72.	373.	0.	47.	16.	1406.	3.	0.
46	781.	797.	1208.	86.	568.	2381.	557.	1102.
47	4.	47.	2.	149.	178.	0.	6.	31.
48	1152.	165.	8.	0.	25.	231.	0.	50.
49	67.	19.	0.	9.	97.	64.	1.	28.
50	25.	6.	0.	0.	0.	14.	0.	0.
51	1558.	0.	321.	826.	256.	0.	282.	0.
52	55.	179.	25.	122.	66.	414.	39.	111.
53	111.	2065.	645.	2347.	711.	0.	1106.	1341.
54	29.	444.	55.	198.	32.	1169.	86.	276.
55	223.	16.	0.	0.	2.	22.	0.	0.
56	10.	7.	6.	0.	28.	18.	16.	0.
57	20.	0.	0.	0.	0.	0.	0.	0.
58	17.	0.	0.	0.	1.	0.	0.	0.
59	2260.	0.	1.	606.	153.	0.	0.	0.
60	66.	81.	0.	0.	49.	181.	0.	0.
61	7.	47.	718.	0.	292.	3.	291.	176.
62	366.	1.	2295.	549.	808.	68.	5309.	2000.
63	15.	431.	505.	1199.	306.	834.	324.	529.
64	59.	513.	29.	201.	60.	472.	25.	118.
65	14.	148.	31.	0.	14.	548.	17.	71.
avg	240.	251.	306.	274.	261.	1175.	322.	266.
corr. coef.		-.074	.015	.346	.280	.254	.013	.084

Da[illegible] Matched by Time and Location

Oklahoma Data

For the OK data set and all tracer data we get the following ranking of skill of the 8 models ability to reproduce the 45 minute tracer observations:

> Ranked 1: MESOPUFF-I and ARM3. Both models exhibit lower bias (48 and 60 percent) and the lowest average absolute error (199 and 126 percent) combined with high correlation coefficients (greater than 0.69). MESOPUFF-I was more accurate with a lower bias and absolute error, but ARM3 had a higher correlation coefficient.
>
> Ranked 2: RTM-II and MESOPLUME. These two models have an absolute error of about 150 percent, with MESOPLUME displaying a fairly high correlation coefficient (0.593) compared to RTM-II (0.179), however, RTM-II does have a positive correlation coefficient at the 95% condifdence limit and the lowest bias (3 percent) of any model.
>
> Ranked 3: MESOPUFF-II and ARRPA. Both models have absolute errors greater than 200 percent and near zero correlation coefficients. MESOPUFF-II has the second lowest bias but is the only model exhibiting a negative correlation coefficient.
>
> Ranked 4: MSPUFF and RADM. A case can be made for ranking MSPUFF higher due to its high correlation coefficient (0.759), however, its bias is over 200 percent and absolute error is almost 300 percent. The RADM appears to systematically overpredict with a bias of over 250 percent and an absolute error over 400 percent.

Savannah River Plant Data

Ranked 1: RTM-II and ARM3. Both models have the lowest bias (7 percent), average absolute error (165 and 171 percent), and, except for RADM, the highest correlation coefficients (0.132 and 0.101) of all the models.

Ranked 2: MESOPUFF-II, MESOPLUME, MSPUFF, and MESOPUFF-I. All four of these models have bias's that range from 14 to 18 percent, absolute error of about 190 percent, and correlation coefficients that range from 0.010 to 0.096. Of these MSPUFF appears to have the least skill with the highest absolute error and lowest coreelation coefficient, but not significantly worse than the other models in this class.

Ranked 3: RADM. Although exhibiting the highest correlation coefficient of any model (0.264), the inaccuracy of the model (285 percent bias and 433 percent absolute error) indicates that the model contains a systematic tendency towards overprediction.

Data Unmatched by Time or Location

Oklahoma Data

Ranked 1: MESOPUFF-II. The MESOPUFF-II predicts both the highest 25 and highest five observed tracer observations within 23 percent.

Ranked 2: MESOPLUME, MESOPUFF-I, and ARM3. The MESOPLUME, MESOPUFF-I, and ARM3 predict the highest 25 and highest five observations to within, respectively, 79, 45, and 55 percent and 79, 76, and 52 percent. The ARM3 exhibits more skill at predicting the highest observations than the other two models in this ranking, but is still not showing as much skill as MESOPUFF-II for this category.

Ranked 3: RTM-II. The RTM-II is the only model that is almost as accurate as the MESOPUFF-II in replicating the highest observations predicting the highest

25 and five observations to within 32 percent. However, the RTM-II is the only model that underpredicts the highest observed tracer observations. For regulatory purposes it is important to be conservative, i.e. tend towards overprediction of the peak observations, thus the RTM-II is ranked below some of the other models that are less accurate in this category. Note that based on accuracy alone, the RTM-II would be ranked in the highest category.

Ranked 4: RADM and MSPUFF. Both models overpredict the 25 and five highest observations by over a factor of two and are the least accurate of the models examined.

Savannah River Plant Data

Ranked 1: MESOPUFF-II. The MESOPUFF-II predicts the 25 and five highest observations for the SRP data set to within 8 and 12 percent.

Ranked 2: RTM-II and ARM3. These two models predict the 25 highest observations to within 4 and 2 percent, respectively. However, the RTM-II and ARM3 underpredict the five highest observations by, respectively, 9 and 15 percent. Despite the fact that the RTM-II and ARM3 are more accurate in predicting the peak observations than the MESOPUFF-II, the model attribute to be conservative in predicting peak observations is important enough to rank the models below MESOPUFF-II in this category.

Ranked 3: MESOPUFF-I, MESOPLUME, and MSPUFF. The MESOPUFF-I, ARRPA, and MSPUFF predict the 25 and five highest observations to within, respectively, 33 to 44 percent and 38 to 58 percent.

Ranked 4: RADM. This model overpredicts the 25 and five highest observations by about a factor of 4 and 6 respectively.

Data Matched by Time but Not Location

Oklahoma Data

Ranked 1: MESOPUFF-II, MESOPUFF-I, and ARM3. All three models predict the average of the maximum observation for each sampling interval to within a factor of two and correlate well (0.64 to 0.84)

Ranked 2: MESOPLUME and ARRPA. These two models predict the average of the maximum observations for each sampling interval by a little over a factor of two and both exhibit correlation coefficients of about 0.6.

Ranked 3: RTM-II. The RTM-II underpredicts the average of the maximum observations for each experiment by a little over a factor of two and has the lowest correlation coefficient (0.354) of any model for this category.

Ranked 4: MSPUFF and RADM. The MSPUFF and RADM overpredict the average of the maximum observations by a factor of 3.3 and 5.2, respectively.

Savannah River Plant Data

Ranked 1: RTM-II. The RTM-II overpredicts the average of the maximum observations by nine percent and has the second highest correlation coefficient (0.280) in this category.

Ranked 2: MESOPUFF-II and ARM3. The MESOPUFF-II predicts the average of the maximum observations to within 5 percent but is the only model that exhibits a negative correlation coefficient in this category (-0.074). The ARM3 predicts the average of the maximum observations to within 11 percent and has a slight positive correlation coefficient (0.084).

Ranked 3: MESOPLUME and MESOPUFF-I. These two models both predict the average of the maximum observations to within about 30 percent and both have slightly positive correlation coefficients of less than 0.02.

Ranked 4: RADM. RADM overpredicts tha average of the maximum observations by almost a factor of five.

Final Ranking of the Models

In order to obtain an overall ranking of the eight mesoscale transport models ability to reproduce the tracer observations in the Oklahoma and Savannah River Plant data bases we combine the above ranking in each category into a final model ranking. For each of the six categories above a model receives a score of four if it is ranked first, three if ranked second, two if ranked third, and one if ranked fourth. An overall model ranking is then obtained by adding up the models score in each of the six categories. Note that this is somewhat a subjective and arbitrary methodology for ranking the models. Some may want to score the models ability to replicate all observations (matched by time and location) higher than the categories involving maximum observation. However, most EPA-approved models are evaluated by their ability to reproduce the maximum observations, therefore we feel that this methodology is a fair and as objective as possible and is only intended to give a relative score for obtaining a relative ranking of the performance of the 8 models. Based on the above scoring system, in which a maximum 24 points is possible, we get the final model ranking:

Model	Score
ARM3	21
MESOPUFF-II	20
RTM-II	18 (tied)
MESOPUFF-I	18 (tied)
MESOPLUME	16
ARRPA	8 (out of a possible of 12 points)
MSPUFF	11
RADM	7

The best performing models are the ARM3 and MESOPUFF-II. The ARM3 is more accurate in predicting all observations (matched by time and location), whereas, the MESOPUFF-II is slightly better at predicting the very highest observations (unmatched by time or location).

The second best performing models in this study were the RTM-II and MESOPUFF-I. The RTM-II tended to match the observations from the SRP data set better, while, the MESOPUFF-I predicted a better match the observations from the OK data set.

The next models in the ranking were the MESOPLUME and ARRPA, although the ARRPA was only exercised for the OK data base. The MSPUFF was ranked next and illustrated some skill in predicting the observations from the SRP data set but greatly overpredicted the observations from the Oklahoma data set. The worst performing model was the RADM which tended towards systematic overprediction.

5 SUMMARY AND RECOMMENDATIONS

The evaluation of the ARM3 was accomplished in several tasks:

> The diagnostic (or scientific) evaluation in which the formulation of the model was examined by evaluating the treatment of the parameterizations of the major processes (transport, dispersion, chemical transformation, dry deposition, wet deposition) of acid deposition in the Rocky Mountains. The diagnostic evaluation was performed as part of the model development process and is reported in Morris et al., (1987).
>
> The evaluation of the wind model component of the ARM3. A preliminary evaluation was reported in Morris et al., (1987), a more complete evaluation is included in Appendix C of this report, and a detailed evaluation of the wind model can be found in Kessler and Douglas (1988).
>
> The comparison of the Lagrangian puff model component of the ARM3 (CONDEP) with two EPA-approved Gaussian plume models: ISC and MPTER. This comparison is presented in Appendix B.
>
> The evaluation of the complete ARM3 modeling system using tracer data from the Oklahoma and Savannah River Plant data sets. The model performance was then compared with up to 7 other mesoscale air quality simulation models.

In general, the model performance statistical results calculated indicated that the performance of the ARM3 was as good or better than the other mesoscale air quality models. However, care should be taken in the interpretation of these statistical measures. As noted in our analysis, the performance of a model varies depending on which measures of model performance is examined: ability to predict observations matched in time and location or ability to predict peak observations. In an analysis of modeling results by McNider (1987) he emphasized the model performance measures of accuracy of trajectory and accuracy of plume spread. These are also good measures of model performance, but time constraints limited our evaluation to the performance measures presented. Future studies should examine this component of model performance. McNider (1987) also presented an approach for improving trajectory and dispersion parameterizations, however the use of these more computationaly extensive procedures in a model that was designed to be computationally efficient and run for an entire year, such as the ARM3, is questionable.

Although the model performance of the ARM3 was comparable or better than the other mesoscale models, further evaluation should be conducted. Additional measures of model performance as suggested by McNider (1987) should be calculated for the Oklahoma and Savannah River Plant data bases. As discussed in the modeling protocol (Section 3), the ARM3 should also be evaluated using the EPRI Kincaid data base. With this data base the ARM3 model performance can be compared with that of EPA-approved (EPA, 1986) regulatory Gaussian plume models. In addition, other options in the ARM3 (e.g., dispersion and plume height corrections) need to be examined to determine the validity of these other options.

The evaluation of the ARM3 should also include model refinements in order to improve the model formulation. For example, the parameterization of processes from a dynamic meteorological model, as suggested by McNider (1987), may improve the accuracy of the ARM3 trajectory and dispersion calculations.

Finally, the ARM3 should be evaluated for the purpose for which it was designed: predicting long-term acid deposition (wet and dry sulfur and nitrogen deposition) and short-term and long-term concentrations in the complex terrain of the Rocky Mountains. Currently there are no appropriate data bases to carry out this evaluation and more research in this area is necessary.

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Appendix A

MODEL EVALUATION PROTOCOL FOR THE ARM3

A useful guide to preparing model performance evaluation protocols is the US EPA's "Interim Procedures for Evaluating Air Quality Models" (EPA,1985). The steps needed to obtain EPA's acceptance of an air quality simulation model for use in regulatory decisions are shown in Figure A-1. The model performance evaluation protocol is a major step in obtaining the EPA's acceptance of a model. The evaluation protocol should describe how an appropriate set of field data will be selected, how to evaluate the proposed model, and how to compare the performance of the proposed model with that of other air quality models.

In view of the objectives of the EPA's air quality modeling guidelines (EPA, 1986) and the Rocky Mountain Acid Deposition Model Assessment Project we have defined the following criteria for evaluating the ARM3.

> The model evaluation must provide some indication of the ability of the ARM3 to predict short-term and long-term concentration impacts and long-term sulfur and nitrogen deposition in complex terrain in the western US over downwind distances of 5-250 km.
>
> The model evaluation must compare the ARM3 model performance with the performance of EPA-recommended models using observed data. The intent is to demonstrate performance equivalent or superior to the EPA-recommended models.
>
> The model evaluation must include a scientific evaluation in which each component of the model is evaluated separately to assure that the model is based on sound fundamental scientific principles.

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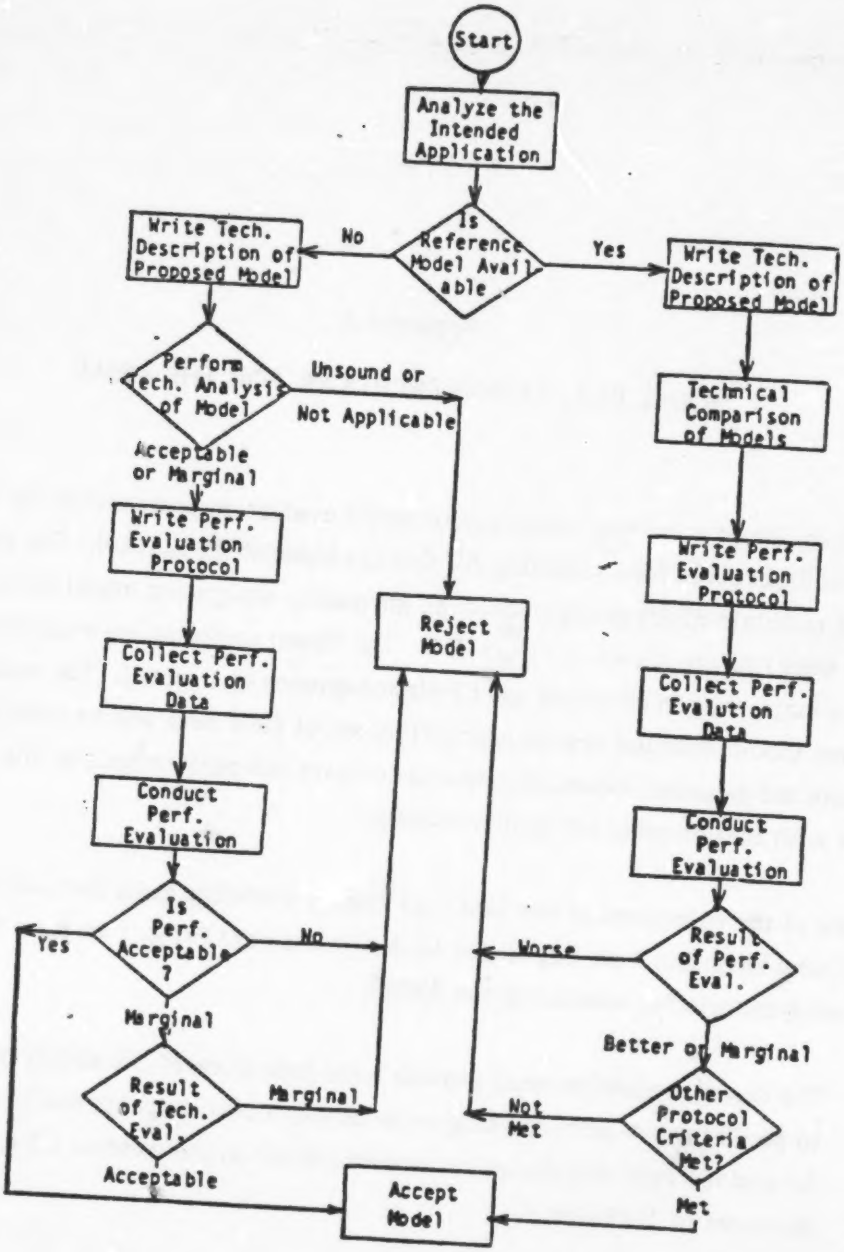

Start
Analyze the Intended Application
Is Reference Model Available
No
Yes
Write Tech. Description of Proposed Model
Write Tech. Description of Proposed Model
Perform Tech. Analysis of Model
Unsound or Not Applicable
Acceptable or Marginal
Technical Comparison of Models
Write Perf. Evaluation Protocol
Write Perf. Evaluation Protocol
Reject Model
Collect Perf. Evaluation Data
Collect Perf. Evalution Data
Conduct Perf. Evaluation
Conduct Perf. Evaluation
Is Perf. Acceptable ?
Yes
No
Worse
Result of Perf. Eval.
Marginal
Better or Marginal
Result of Tech. Eval.
Marginal
Not Met
Other Protocol Criteria Met?
Acceptable
Accept Model
Met

FIGURE A-1. Decision flow diagram for evaluating an air quality model. (From EPA, 1985)

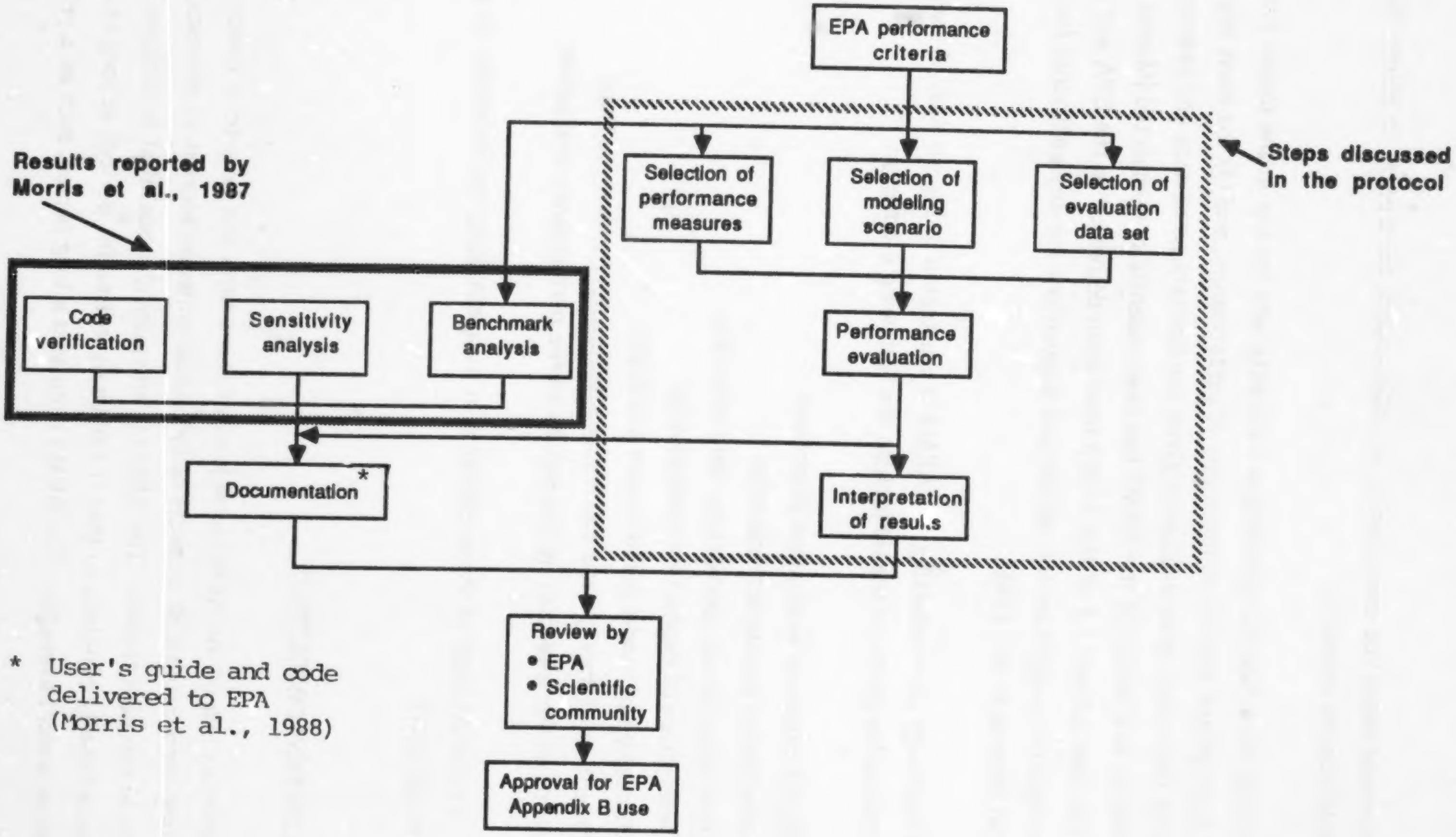

Results reported by Morris et al., 1987
Steps discussed in the protocol
EPA performance criteria
Selection of performance measures
Selection of modeling scenario
Selection of evaluation data set
Performance evaluation
Interpretation of resul.s
Code verification
Sensitivity analysis
Benchmark analysis
Documentation*
Review by
• EPA
• Scientific community
Approval for EPA Appendix B use
* User's guide and code delivered to EPA (Morris et al., 1988)

FIGURE A-2. The process for evaluating the ARM3 system. Documentation of the initial versions of ARM3 has been completed.

The model should be exercised by an independent third party to assure that results can be repeated.

Thus we have identified (1) appropriate field data sets for use in the model evaluation, (2) appropriate statistical measures of performance, and (3) the most important features of the model to be evaluated given the limitations of data and resources. The scientific evaluation of the ARM3 has been essentially completed (Morris et al., 1987). Versions 1.0 and 1.1 of the ARM3 have been delivered to the EPA and several western regulatory agencies for testing and suggestions for any additional features in the model (Morris et al., 1988).

The methodology for evaluating the ARM3 is illustrated in Figure A-2. A complete model evaluation protocol should include the following elements:

Identification of evaluation objectives
Selection of evaluation scenarios
Determination of appropriate field data sets
Description of evaluation methodology
Discussion of model performance attributes
Selection of appropriate statistical measures,tests, and graphics
Methods for interpreting the results of the performance evaluation

Below we discuss each of these elements in turn, outlining the rationale for the procedures selected.

EVALUATION OBJECTIVES

The primary use of the ARM3 is to predict short-term and long-term concentration and long-term deposition impacts of individual emission sources at mesoscale distances in complex terrain. The ARM3 is an episodic model that is designed to be computationally efficient so that it can be exercised for periods as long as a year to generate annual averages. The ARM3 simulates a long period, such as a year, by using integration time steps of an hour or less. The model generates hourly concentration and deposition impacts. Longer-term deposition or concentration impacts are obtained by summing or averaging the hourly values, i.e., they are based on estimates of a series of short-term impacts. The proper specification of the short-term events will lead to accurate estimates of the longer-term concentration and deposition impacts. Thus, evaluation of ARM3 performance for short-term episodes should receive higher priority than evaluation of its performance for long-term periods. Statistical measures of performance that are more suited to short-term evaluation will receive more attention than those more suited to long-term averages.

Another factor affecting the evaluation of the ARM3 is that, although atmospheric concentrations of chemicals have been regulated for several years, only recently has deposition of airborne chemicals become a major concern. As a result, data bases and model performance measures are directed more to evaluating single-source air quality models than to evaluating deposition models. Thus there is no adequate data base to evaluate the ARM3's ability to predict deposition impacts. As noted earlier, in order to evaluate the Regional Acid Deposition Model for acidic deposition, the EPA recently initiated a comprehensive measurement program that will be completed sometime in 1990.

The model performance evaluation should therefore focus on the following performance attributes:

Bias in episodic (short-term) calculations

Spatial displacement of maximum deposition regions for both short-and long-term averages

Bias in long-term calculations

Variability in the calculated long-term deposition pattern

The ARM3 will be used to assess the impacts of maximum concentrations and deposition amounts at acid-sensitive areas. Thus it is important to know whether the model is over- or underestimating concentration and deposition impacts. It is also important to determine whether there is any systematic bias in the displacement of the concentrations and deposition fields. This is particularly important for "Prevention of Significant Deterioration" (PSD) permit applications, when a small displacement may make the difference between an impact or no impact at a PSD class I area.

SELECTION OF EVALUATION SCENARIOS

Morris and Kessler (1988) describe two hypothetical yet typical application scenarios for ARM3. The first scenario includes a shale oil plant in western Colorado, the other scenario includes three gas treatment plants in southwestern Wyoming. The modeling domain is expected to be on the order of 250 km on a side with a grid resolution on the order of 5-10 km. The model is designed to predict both short- and long-term concentration impacts and long-term (e.g., month to a year) deposition amounts.

Based on our review of available field data bases (see Section 2), it appears that existing data bases can only evaluate the transport and dispersion components of the ARM3. This is not to say that the evaluation of the chemical transformation and deposition components of the ARM3 are not important, just that currently available data bases cannot support the evaluation of these processes.

We identified three types of data sets for evaluating the transport and dispersion elements of the ARM3: extensive meteorological monitoring data for evaluating the wind model component of the ARM3, and near-source and intermediate distance tracer data for evaluating trajectory and dispersion.

Extensive Meteorological Data

To evaluate the wind model component of the ARM3, the Diagnostic Wind Model (DWM), we will rely on DWM simulations carried out for the U.S. Minerals Management Services (MMS) for the South Central Coast district of California. This region was the location of a massive meteorological and air quality measurement program known as the South Central Coast Cooperative Aerometric Monitoring Program (SCCCAMP) in 1984 and 1985. An initial evaluation of the DWM for this region was reported by Morris et al. (1987).

We plan to perform a more detailed evaluation of the DWM by using only routine measurements comparing wind fields predicted by the DWM with those obtained using the intensive measurement and comparing the predicted wind flows with the observations. This evaluation is diagnostic in nature because point observations of wind are not representative of the grid-cell average wind vector calculated by the model.

Near-Source Dispersion Data

For testing the accuracy of the trajectory and dispersion components of ARM3 in predicting near-source concentration impacts, we have determined that:

> The deposition and transformation components are not important, and
>
> There must be a sufficient number of stations (more than 20) to resolve the spatial characteristics of the concentration field, and
>
> There must be enough data to resolve both short-term (less than one day) averages and long-term averages.

Of the near-source tracer experiments reviewed (Table 2-2), the data sets that seems most suitable are the SO_2 and SF_6 data from the EPRI PMV&D experiment at Kincaid. The Rocky Flats data base contains insufficient data for longer-term evaluation and has not been used to evaluate EPA-recommended models. The EPRI PMV&D Bull Run data base is not as complete as the Kincaid data and has not been used to evaluate as many models. The Tracy data set contains only a limited number of sites and these are too close (within 10 km) to the release point, and the number of hours (128) is insufficient for evaluating long-term average calculations.

The SF_6 tracer experiments at Kincaid were conducted over three four-week periods of intensive measurement during the late spring and summer of 1980 and 1981. It would be desirable to use the SF_6 tracer observations at the surface to evaluate the ability of ARM3 to simulate dispersion near the source for averaging periods up to 9 hours. Measurements of SO_2 at Kincaid were made during the 16-week period of April 21 to July 28, 1980. The SO_2 data base would be used to evaluate the ARM3 calculations of both short-term and long-term (seasonal) average concentrations. These data sets have been used to evaluate the EPA-recommended CRSTER and EPA-approved alternative Texas Episodic Model (TEM). The intensive SF_6 experimental data have been used to evaluate two first-order-closure models, the Systems Applications, Inc. Plume Dispersion Model (PDM) and the Lawrence Livermore National Laboratory ADPIC. The PDM is a version of the EPA-approved Urban Airshed Model that contains a point source module and no chemical mechanism, while the ADPIC model was the only nonsteady-state model that was recommended by the Nuclear Regulatory Commission.

Intermediate Distance Data

Most of the longer-distance tracer experiments reviewed were designed for regional-scale evaluations. For evaluations of short-term model calculations the only experiments that combine sufficient spatial resolution to test the ARM3 are the Savannah River Plant and the Oklahoma tracer release experiments.

The Oklahoma experiment (summarized in Table 2-3) is of limited usefulness since only the receptors at the 100 km arc are of direct use in evaluating the ARM3 for its intended application. The other receptor arc is 600 km downwind of the source. The experiment was conducted over nearly flat terrain and for a limited number of release hours, thus ruling out any averaging periods greater that 12 hours. An advantage of the Oklahoma experiment is the fact that eight short-term long-range transport models have been evaluated with these data (Policastro et al., 1986). The model predictions from these evaluations are available and can be used in the evaluation of ARM3. Another advantage of the Oklahoma experiment is that it contains a high-density network of receptors 100 km from the source that can be used to evaluate the dispersion algorithms in the ARM3.

The Savannah River Plant releases of ^{85}Kr covers a much longer time period than the Oklahoma releases. The field data from this study were also used to evaluate the same eight short-term long-range dispersion models evaluated using the Oklahoma data. Thus we suggest that the Oklahoma evaluation of data set be used for evaluating very short-term (<12 hour) calculations and the Savannah River Plant data set be used for slightly longer averaging times.

No source-specific field experiments of tracer or acidic deposition species has been conducted. Cumulative wet deposition of sulfur and nitrogen has been measured, by for example the NADP acid deposition network, and these may be used for evaluating the wet deposition component of the ARM3. As noted before, the major difficulty in using these cumulative measurements to evaluate the ARM3 is that one would need to select a combination of period and site in which emissions from one source or group of sources of sulfates and nitrates predominates. This is especially difficult since most of the sulfates and nitrates in the Rocky Mountains comes from outside the region (Pielke, 1986).

MODEL PERFORMANCE METHODOLOGY

The model performance evaluation will be carried out like an operational model evaluation using observational data. However, in the strictest sense the evaluation is not a full operational evaluation since (1) the model is being tested in application to a region other than the one that it has been developed for, and (2) the model is being evaluated only for concentration impacts and not for deposition. These limitations in the evaluation exercise are necessitated by the lack of suitable data bases. The evaluation will focus on the ability of the ARM3 to predict source-receptor relationships over mesoscale distances. It is hoped that this operational evaluation of this ability of ARM3 along with the diagnostic evaluation of other components of the ARM3 (Morris et al., 1987) will provide a basis for establishing the credibility of the ARM3 as a modeling tool for regulatory decision making.

None of the models previously evaluated using the data from the Kincaid, Oklahoma, or Savannah River Plant experiments seems appropriate for comparison with ARM3 at both short and intermediate distances. The EPA-approved (Appendix A) CRSTER

Model and the alternative (Appendix B) Texas Episodic Model would be used to compare the model performance of the ARM3 using the near-source Kincaid experiments. The CRSTER and TEM models are described in the Guideline on Air Quality Models (EPA, 1986).

The results of the performance evaluation for eight short-term long-range transport models using the Savannah River Plant and Oklahoma tracer experiments are available (Policastro et al., 1986). To assess the performance of the ARM3 over intermediate distances we will compare its performance with the eight models, five of which are EPA-approved alternative (Appendix B) models.

In summary, we recommend that the evaluation of the ARM3 be carried out in the following order:

1. Evaluation of the wind model component of the ARM3 using the SCCCAMP data base.

2. Short-term, intermediate distance calculations compared against the Savannah River Plant and Oklahoma data sets. Model performance compared with MESOPUFF, MESOPLUME, MSPUFF, MTDDIS, ARRPA, RADM (Lagrangian random walk), and RTM-II models.

3. Long-term, intermediate distance: using the Savannah River Plant data. Model performance compared with the same models as in (2).

4. Short-term, near source calculations compared against the EPRI Kincaid SF_6 data. Model performance compared with the CRSTER and TEM models.

5. Long-term, near source calculations compared against the EPRI Kincaid SO_2 data. Model performance compared with CRSTER and TEM models.

Available resources have limited the model evaluation exercise to only Tasks 1 through 3 above. Future studies should continue the ARM3 model evaluation using the EPRI Kincaid data base among other things.

MODEL PERFORMANCE ATTRIBUTES

Most model evaluations use a somewhat standard set of statistical measures. However, there are some major differences between the evaluation of most other air quality models and the evaluation of ARM3. Since there are no regulatory standards for deposition, a more long-term phenomenon, the evaluation will put less emphasis on peak predictions. Instead, because of PSD concerns for new sources, there is considerable interest in the model's ability to predict the higher concentrations and deposition rates in the right locations. Attributes of peak concentrations will be examined since these attributes are of most interest in EPA-recommended models.

The model performance attributes we will address, using various statistics, are:

> Lack of systematic bias in model predictions, not only for the N highest atmospheric concentrations and deposition rates, but for the entire range of concentrations and deposition rates.
>
> Accuracy in predicting peak concentrations (i.e., the highest values during an episode) as well as the upper 2 to 5 percent of the observed concentration distribution.
>
> Lack of spatial offset or spatial transformation in estimating the location of regions of concentrations or depositions.
>
> Lack of bias in the spatial patterns of maximum concentrations or deposition rates.
>
> Agreement between the observed and predicted spatial variability in the pattern of ambient concentrations and deposition rates.

Observations and predictions can be matched in a number of ways. For a performance evaluation the type of matching depends mainly on the questions that are being asked, and an anticipation of how the results of the evaluation will be interpreted.

For example, a standards-based interpretation might focus only on the peak N concentrations matched by rank only. This is because the interest is on the number and degree of exceedances of an ambient air quality standard.

If questions of exposure are asked, then the evaluation of the model's ability to predict spatial patterns is of most interest. Therefore a matching by space but not by time would be relevant. This consideration is particularly important for long-term modeling, where the characteristics of short-term episodes are less important than a cumulative measure.

Because peak values are of interest when evaluating EPA guideline models, we propose to examine the highest 25 predictions and observations matched only by rank. Because we are interested in evaluating both short-term and long-term calculations we will match the predicted and observed 25 highest concentrations for each data base. In addition, we will compare the peak prediction and observation from each experiment in a data base.

In addition to the N highest we will examine the highest and second-highest values (matched by rank only) for each data set. Finally, in order to determine both time and spatial correlation, we will match the data by both site and averaging period (and/or episode).

MODEL PERFORMANCE MEASURES

Since the mid-1970s considerable work has been done to develop procedures for evaluating air quality model performance. (See for example Nappo, 1974; Bencala and Seinfeld, 1979; Bornstein and Anderson, 1979; Hayes, 1979; Hillyer, Reynolds, and Roth, 1979; Bowne, 1980; Londergan et al., 1982; Fox 1981; Fox, 1984; Hayes, Moore, and Langstaff, 1984; Dennis, Downton, and Keil, 1983; and Schere and Shreffler, 1982.) From these and other studies we have compiled a list of quantitative and qualitative procedures for evaluating the performance of various types of air quality models. The Statistical Performance Evaluation Software (SPES) package, developed by Systems Applications, would be used to evaluate pairs of observations and ARM3 predictions, as well as predictions of the models that have been evaluated previously using the three tracer data bases. The statistical measures routinely calculated by SPES are summarized in Table A-1.

We are very aware that statistical measures by themselves do not provide a complete picture of a specific performance attribute, such as bias. Plots of statistical data provide much needed visual confirmation of findings. Some of these evaluation graphics are summarized in Table A-2. In addition, Systems Applications has developed a number of specialized plots that compare model predictions and observations. For example, point observations can be superimposed on an isopleth field, as in Figure A-3. (The ozone isopleths in Figure A-3 were generated by a regional oxidant model using wind fields from the same wind model in the ARM3). As part of the model performance evaluation we would interpret such graphic displays.

In the last decade concern has grown over the effects of various sources of uncertainty on the interpretation of model performance statistics. It is generally recognized that due to measurement uncertainty, and the uncertainty in comparing dissimilar measures (i.e., point observations versus calculated grid averages) and limited samples, there is a limit to how even a perfect model may be expected to agree with observations. When statistical tests for significance are applied to such performance measures as the average residual, it is often found that over- or under-prediction bias is not significant. In view of that fact that uncertainty can obscure the interpretation of a model's performance, it is vital to include some measure of the significance of each model performance statistic. One of the simplest methods is to calculate a confidence interval around the statistic. Some of the methods that can be used to estimate confidence intervals are also summarized in Table A-1. These confidence intervals for the 90 percent level are routinely estimated by SPES and would be reported in the ARM3 performance evaluation.

METHODS FOR INTERPRETATION OF EVALUATION RESULTS

One must be extremely careful in interpreting statistics. It is very easy for one exceptionally poor performance attribute to create difficulty in properly interpreting statistics that describe other model attributes. Examples of these difficulties include the following:

TABLE A-1. Quantitative performance measures recommended for ARM3 evaluation. Concentration units are used in this table only as an example; measures may be calculated for wet deposition, ratios of concentrations, etc., depending on the test.

Measure	Mathematical Definition	Interpretation of Measure	Method for Calculating Confidence Interval
d	$d = C_o(x, T) - C_p(x, T)$	Difference in concentration based upon a pair of concurrent predicted and observed concentrations, C_p and C_o.	--
$\overline{d}$	$\overline{d} = \frac{1}{N} \sum^{N} [C_o(x, T) - C_p(x, T)$	Estimate of the bias (signed) of the concentration difference. First moment of the distribution of residuals.	Student t-statistic: $\frac{\overline{d} - t_\alpha \sigma_d}{(N-1)^{1/2}} < \mu_d < \overline{d} + \frac{1_{r-\alpha} \sigma_d}{(N-1)^{1/2}}$ where α = confidence level (e.g., 0.05 = 5 percent level)
S_d^2	$S_d^2 = \frac{1}{N-1} \sum^{N} (d - \overline{d})^2$	Estimate of the variance of the concentration difference. Second moment of the distribution of residuals.	χ^2 statistic: $\frac{NS_d^2}{\chi_\alpha} < \sigma^2 < \frac{NS_d^2}{\chi_{1-\alpha}}$ where α = confidence level (e.g., 0.05 = 5 percent level)
$\lvert\overline{d}\rvert$	$\lvert\overline{d}\rvert = \frac{1}{N} \sum \lvert d\rvert$	Average absolute gross error of the concentration residuals.	Student pooled t-statistic: for positive and negative d using (n^-, S^-) and (n^+, S^+) with n - 2 degrees of freedom. $(n^+) + (n^-) = N$. (See Hoel, 1962, p. 27, for details).

Continued

TABLE A-1. Concluded.

		Method for Calculating	
Measure	Mathematical Definition	Interpretation of Measure	Confidence Interval
$d_M(L_{(n)}, T_{(n)})$	$d_M(L_{(n)}, T_{(n)}) = C_o(L_{(n)}, T_{(n)}) - C_p(L_{(n)}, T_{(n)})$	Difference between maximum predicted and observed concentrations (paired in time and space).	--
$d_M(L, T_{(n)})$	$d_M(L, T_{(n)}) = C_o(L_{(n)}, T_{(n)}) - C_p(L_i, T_{(n)})$	Difference between maximum predicted and observed concentrations (paired in time).	--
$d_M(L_{(n)}, T)$	$d_M(L_{(n)}, T) = C_o(L_{(n)}, T_{(n)}) - C_p(L_{(n)}, T_i)$	Difference between maximum predicted and observed concentrations (paired in space).	—
$d_M(L, T)$	$d_M(L, T) = C_o(L_{(n)}, T_{(n)}) - C_p(L_j, T_i)$	Difference between maximum predicted and observed concentrations (unpaired in time or space).	—
r	$r = \dfrac{\sum^{N} (\bar{C}_o - C_o)(\bar{C}_p - C_p)}{\left[\sum^{N} (C_o - \bar{C}_o)^2 \cdot \sum^{N} (C_p - \bar{C}_p)^2\right]^{1/2}}$	Pearson moment correlation coefficient based upon paired predictions and observations; measures the degree to which predictions change linearly with observations. (This association need not change linearly.) This measure is scale-invariant.	Fisher z-statistic, where $z = \frac{1}{2} \ln \frac{(1 + r)}{(1 - r)}$ and the confidence interval for z (normal variate) is $z - \beta\sigma_z < \mu_z < z + \beta\sigma_z$ where $\beta = 1.96$ for 95 percent confidence level; $\sigma_z = \frac{1}{(N - 3)^{1/2}}$
Q	$Q = (C_o - C_p)/0.5\,(C_o + C_p)$	Fractional difference between predicted and observed concentrations.	--

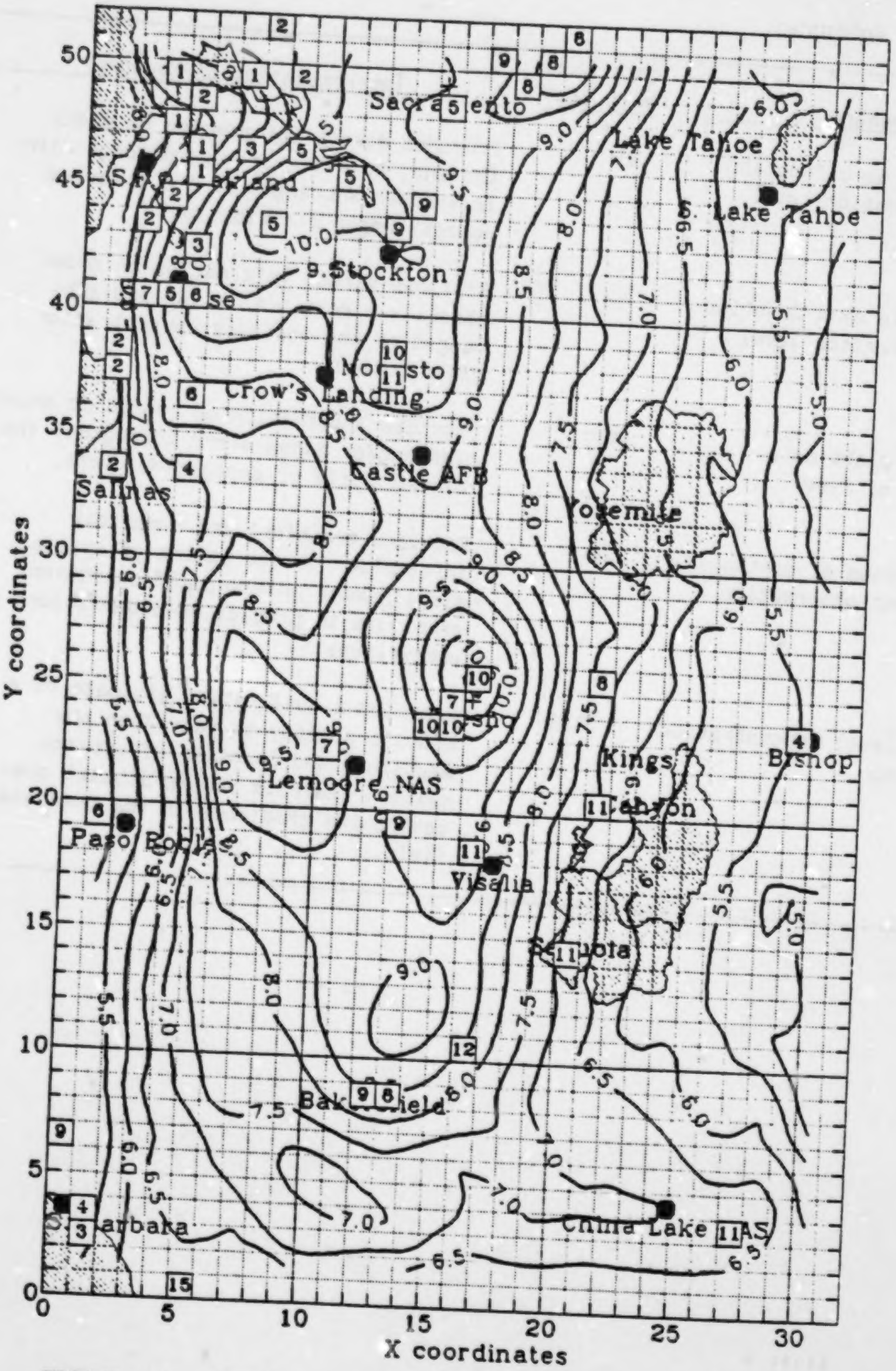
TABLE A-2. Qualitative performance measures recommended for ARM3 model evaluation.

Measure	Shorthand Notation	Interpretation of Measure
Scatter plots of observed versus predictions	SP	Provides a visual assessment of the tendency of a model to over- or underpredict as a function of concentration.
Scatter plots of observed versus residual predictions	SPOR	
Time series plots of predictions versus observations	TS	Provides an evaluation of model's ability to reproduce the magnitude of extreme values (maximum and minimum), time of occurrence of extreme, daytime versus nighttime (stable vs. unstable) occurrences, weekday vs. weekend (high source strength vs. low source strength) effects.
Histograms of observations and predictions	H_o; H_p	
Frequency distribution of concentration observation and prediction residuals	FDR	Provides a visual measure of the model's tendency to over- or underestimate observed concentrations over the entire range. The spread (i.e., variance) of the residual distribution may be qualitatively inferred directly.
Cumulative frequency distribution plots of observed and predicted concentrations	CFDP	Provides direct information on concentration predictions and observations (throughout the entire range or some subrange) that may be used to compare statistical similarities and differences between the two distributions.
Spatial isopleth plots of concentration residuals	SIPR	Provides measures of model over- and underestimation on a subregional basis. Utility of comparison is limited in that interpolation of observed values and/or residuals implies a model of some form (e.g., 1/r, $1/r^2$, kriging).

Continued

TABLE A-2. Concluded.

Measure	Shorthand Notation	Interpretation of Measure
Bias plots as a function of concentration level	BP	Provides direct information on model tendency to over- or underpredict within various subranges of the observed concentration distribution.
Error plots as a function of concentration level	EP	Provides direct information on model absolute errors within various subranges of the observed concentration distribution.
Residual plots as a function of time	RPT	Provides information on trends in model bias and/or gross error throughout the diurnal cycle or deposition event.
Distribution of distances to bracket observation	DD	Provides graphical and numerical information on the extent of spatial misalignment or steep concentration gradients in prediction-observation comparisons.
Ground-level concentration isopleths	GLCI	Provides a qualitative estimate of a model's ability to reproduce the magnitude and location of extreme values. Reveals strong spatial concentration gradients in the predicted field.



Sacramento
Lake Tahoe
S. Lake Tahoe
S.F.
Oakland
Stockton
San Jose
Modesto
Crow's Landing
Castle AFB
Salinas
Yosemite
Fresno
Kings Canyon
Bishop
Lemoore NAS
Paso Robles
Visalia
Sequoia
Bakersfield
China Lake NAS
Santa Barbara
Y coordinates
X coordinates
0
5
10
15
20
25
30
35
40
45
50
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0

FIGURE A-3. Isopleths of predicted mixed-layer concentrations of ozone (pphm) for 1500 LST on August 9, 1981. Observations are shown in boxes.

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Bias can shift distribution locations so that, although the distributions may be exactly the same, comparison tests such as the Kolmogorov-Smirnov test would fail.

Systematic changes in the variance of the observations or predictions can result in false correlations. Associations between the observations and predictions may be improperly stated if the scatter of the observations is very tight but nonlinear.

Systematic shifts in space or time produce worse measures of precision for high-variance predictions than low-variance predictions. As a result, the reported accuracy of model predictions is less than actual because of slight shifts in time or space.

Systematic changes in sample size, e.g., because of missing data, can result in bad interpretation of trends in performance statistics unless confidence intervals are estimated and considered in the interpretation.

The proper interpretation of model performance statistics like those compiled in Table A-1 is helped greatly by visual comparisons of the data through inspection of scatter plots, percentile-percentile plots, time series plots, and co-plots of concentration isopleths and point observations.

According to the EPA's Interim Procedures for Evaluating Air Quality Models (EPA, 1985), some method of scoring the model evaluation statistics based on the objectives of the performance evaluation should be included in a model performance evaluation protocol. To some degree this is unwise because of the potential for a misinterpretation of a statistical measure. Furthermore, since the ARM3 is a new model, it is not possible to refer to past evaluation studies to determine if some attribute is seriously out of line because of poor model inputs, improper usage of the model, or other such factors.

The performance evaluation of the EPA-approved or recommended models using the same data bases will provide a comparison for interpreting the ARM3 evaluation results. Because of the lack of tracer and acid deposition information in the Rocky Mountain region, the interpretation must be qualified by the fact that the evaluation is a preliminary operational evaluation. The interpretation will focus on how well ARM3 performed when compared with the EPA-recommended and alternative (Appendix A and B) models, and whether the model performs conservatively for the types of predictions for which the guideline models may be inadequate.

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Appendix B

COMPARISON OF RESULTS FROM THE ARM3 WITH RESULTS FROM TWO EPA-APPROVED GAUSSIAN PLUME MODELS

The EPA has recommended three models for the treatment of transport and dispersion of inert pollutants in rural, flat terrain regions: CRSTER, ISCST, and MPTER (EPA, 1986). In this section we compare the results from ARM3 with two of the recommended regulatory models, ISCST and MPTER. The CRSTER model was not used in these tests because of its similiarity to the MPTER and its inflexible receptor grid structure.

MODEL INPUTS

Model Inputs for the EPA-Approved Models

The two EPA-approved Gaussian plume models were exercised for a set of 14 meteorological conditions using a polar receptor grid of 300 receptors. The 14 meteorological conditions used in these tests are shown in Table B-1. The receptor grid consisted of 10 radial arcs, with each arc containing 30 receptors with a spacing of 3 degrees starting at the plume centerline. The 10 radial arc distances were 1, 2, 5, 10, 20, 30, 40, 55, 70, and 85 km. Other model input options used for the ISCST and MPTER models were in accordance to the recommendations in the EPA guidelines document for regulatory applications (EPA, 1986). The ISCST model was exercised using the rural option and the MPTER was run specifying the urban option.

For these initial tests, a single source was specified with a stack height of 60 m and an emission rate of 1000 g/s. Other stack parameters were prescribed to assure there was no plume rise; thus the effective stack height of the source was kept at 60 m.

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TABLE B-1. Meteorological conditions used in the evaluation of ARM3 and two EPA-approved models.

Stability	Wind Speed (m/s)	Mixing Height (m)
A	2.0	1000
B	2.5	900
B	4.0	900
C	2.0	700
C	3.5	700
C	5.0	700
D	2.5	900
D	5.5	900
D	7.0	900
D	10.0	900
E	2.5	400
E	4.0	400
E	5.5	400
F	2.5	400

These tests do not represent actual atmospheric conditions. For example, the first test assumes stability class A and a wind speed of 2 m/s. Thus a travel time of approximately 12 hours is required for the plume to reach the farthest receptors--a clear impossibility.

Model Inputs for ARM3

Inputs for the mesoscale meteorological component of ARM3 (METDWM) were defined so as to mimic as much as possible the conditions used by the EPA-approved models. Since it is impossible for the EPA-approved models to simulate the temporal and spatial variable inputs required by ARM3 for these tests, we are forced to attempt to duplicate the simple conditions used by the EPA-approved models.

The ARM3 was run with a region top of 2,000 m and eight vertical layers, with layer tops at 20, 50, 100, 200, 400, 800, 1,200, and 2,000 m. A single upper-air sounding was input for each test, with the vertical wind speed profile defined by the default power law exponents used by the ISCST and MPTER models. The time of day and cloud cover input into the meteorological model were specified to reproduce the stabilities listed in Table B-1. The mixing heights were prescribed as the values listed in Table B-1.

The conditions listed in Table B-1 do not uniquely define the meterological conditions produced by the meteorological component of the ARM3. In this model, stability is a continuous function whose presence is felt in many meteorological variables, including Monin-Obukhov length, friction velocity, and convective velocity. Thus the distinction between two adjacent stability classes in the meteorological model is rather fuzzy, the main distinction being between unstable (negative Monin-Obukhov length) and stable (positive Monin-Obukhov Length).

The acid deposition/air quality module of the ARM3 was run for 24 hours in order for the hourly concentration fields at the 300 receptors to reach quasi-steady-state conditions. The hourly meteorological input data set that corresponds to one of the 14 test conditions in Table 1 was repeatedly input ARM3 for each hour of the 24-hour simulation. The resultant concentrations were then paired with the results generated by the ISCST (RURAL) and MPTER (URBAN) so that a statistical comparison of the concentration distributions produced by the three models could be made.

QUALITATIVE COMPARISON

The plume footprints for the three models for unstable conditions are shown in Figure B-1. The ARM3 produces the widest plumes, followed by the ISCST, while the MPTER predicts the narrowest plumes. The width of the plume in ARM3 is dependent on wind speed, while the other two models produce the same plume width regardless of wind speed. In fact, for the highest wind speed under unstable conditions (C stability, 5 m/s), the plume width calculated by ARM3 is slightly less than that produced by MPTER. This is because dispersion in the ARM3 model is time dependent, while the other two models parameterize dispersion based on downwind distance.

The dependence of dispersion on time rather than downwind distance for ARM3 is further illustrated under neutral conditions (Figure B-2). The plume width calculated by ARM3 at 85 km downwind varies from 30 km (10 m/s) to 55 km (2.5 m/s), while at the same distance downwind the MPTER and ISCST models have plume widths of 25 and 17 km for all wind speeds.

During stable conditions the plume spread produced by ARM3 is greatly reduced; plume widths are now comparable with those produced by ISCST (Figure B-3). The MPTER still produces the narrowest plumes over all wind speeds. Since there was no terrain in these tests, the Rocky Mountain model was exercised using Irwin's dispersion formulas rather than those of MacCready, which rely on terrain roughness for stable disperion rates. The use of the MacCready scheme can produce high dispersion rates under stable conditions if the terrain is rough (see Morris et al., 1987).

There are some differences in the response of ARM3 and the EPA-approved models to changes in atmospheric stability during unstable and neutral conditions. Under these conditions the plume width of ARM3 is more dependent on wind speed than on atmospheric stability. All three models produce lower concentrations under higher

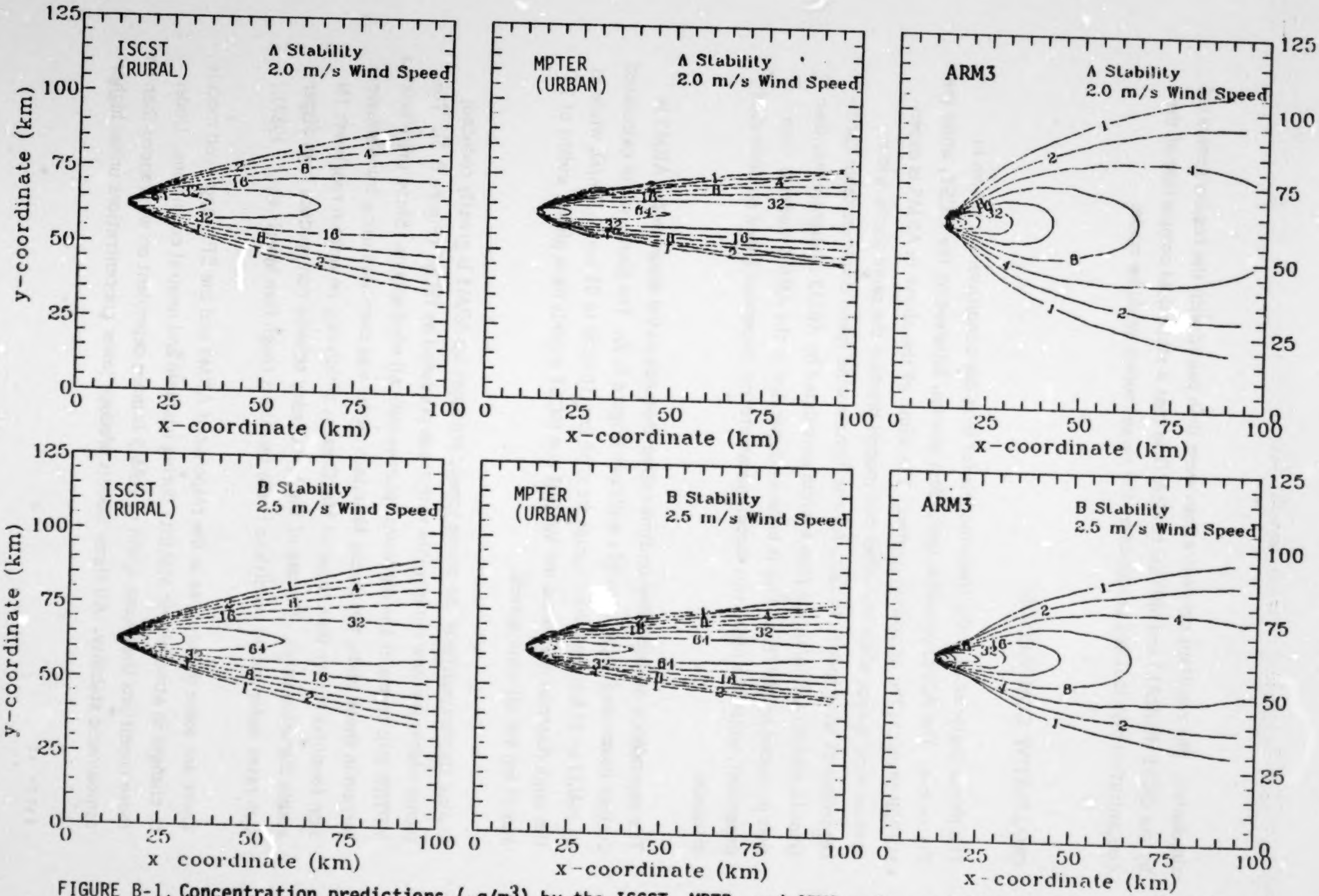

FIGURE B-1. Concentration predictions ($\mu g/m^3$) by the ISCST, MPTR, and ARM3 under unstable conditions (stability classes A, B, C). Emission rate = 1000 g/s.

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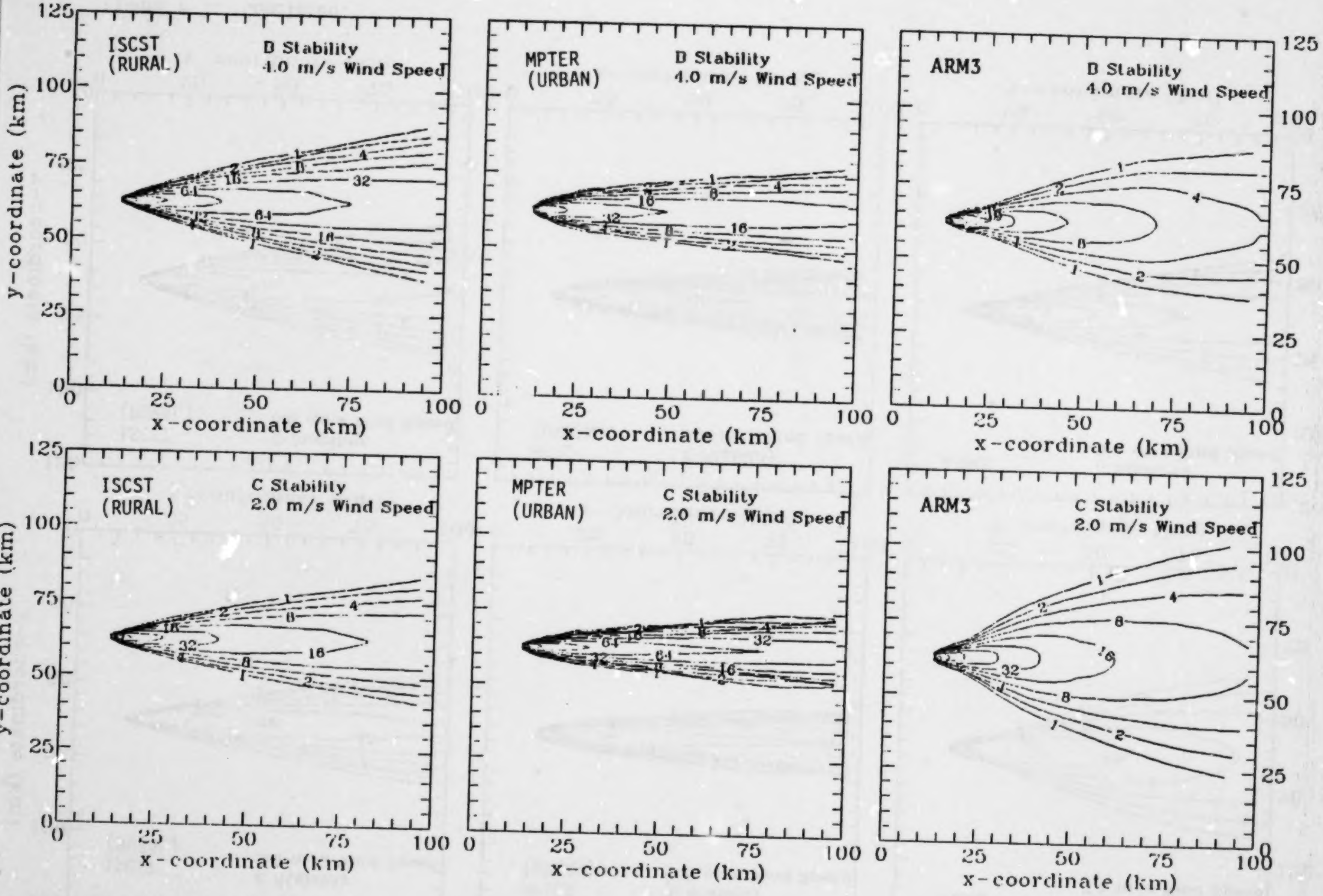

FIGURE B-1. Continued.

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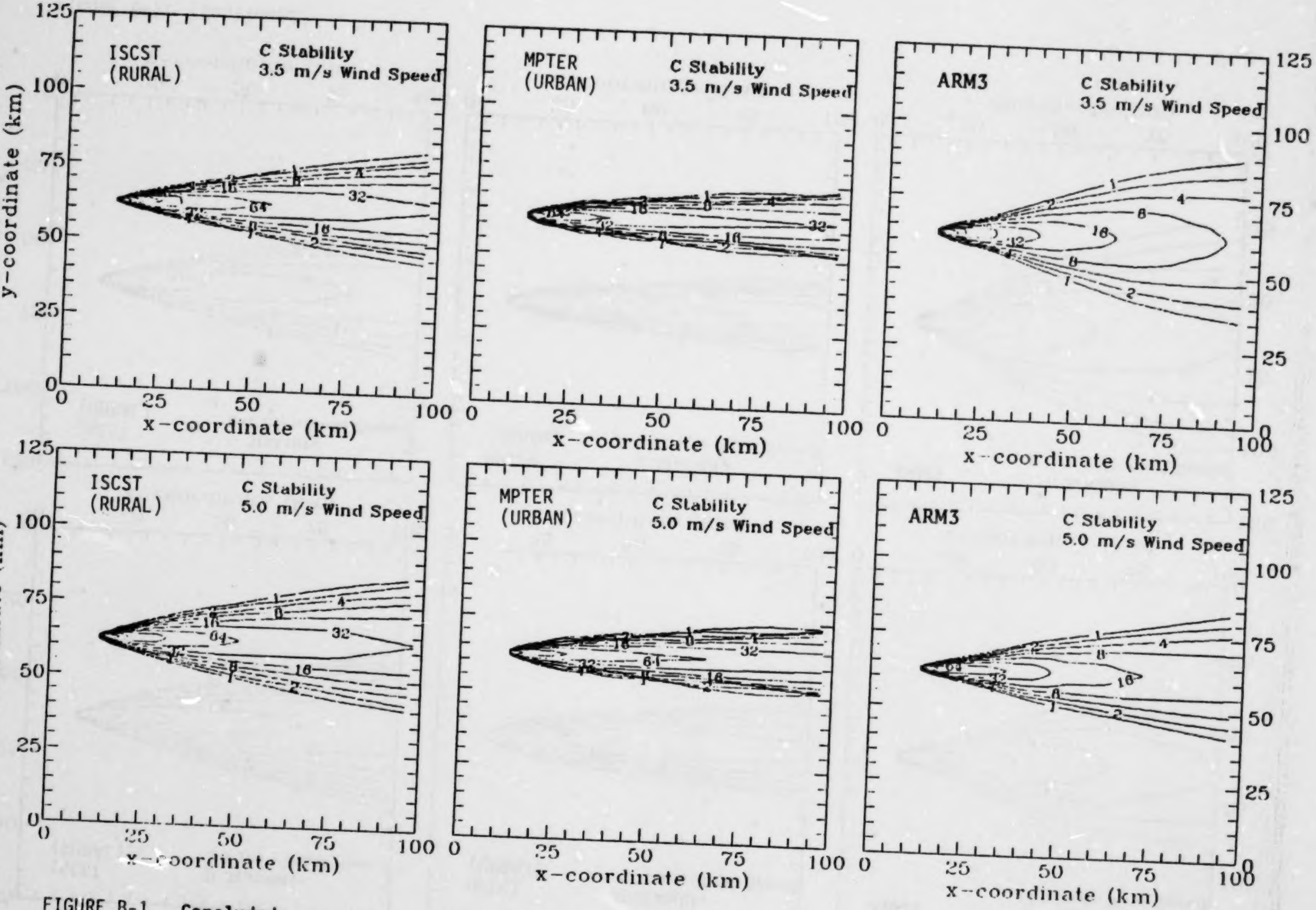


FIGURE B-1. Concluded.

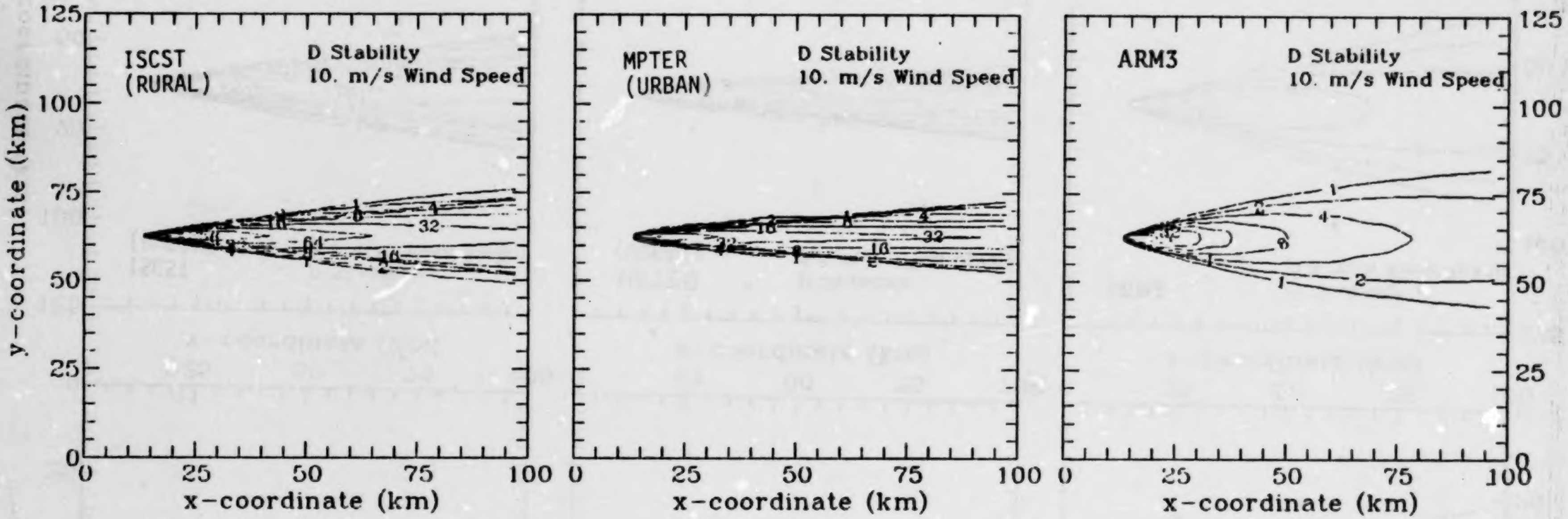


FIGURE B-2. Concentration predictions ($\mu g/m^3$) by the ISCST and ARM3 under neutral conditions (stability class D). Emission rate = 1000 g/s.

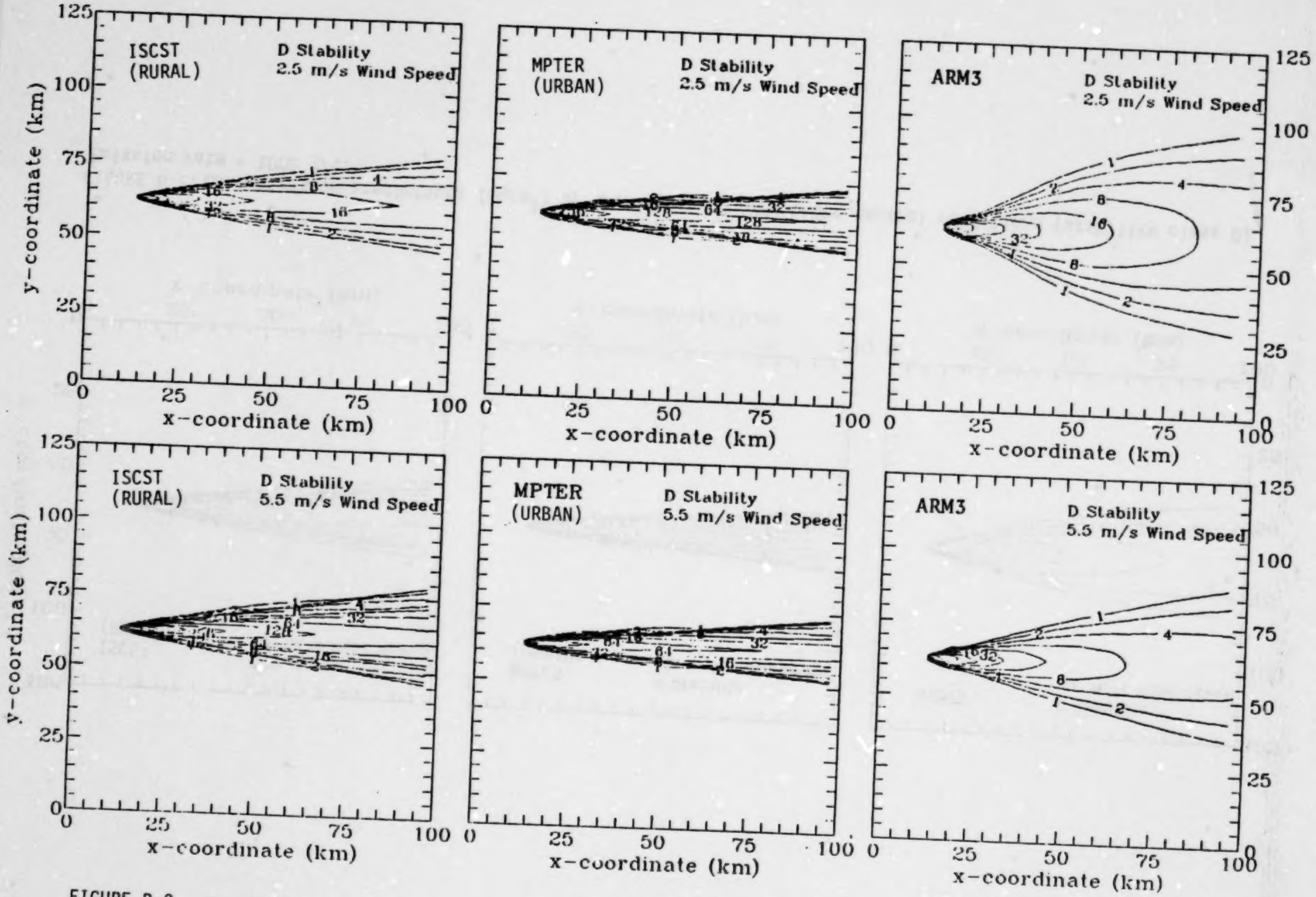


FIGURE B-2. **Concluded.**

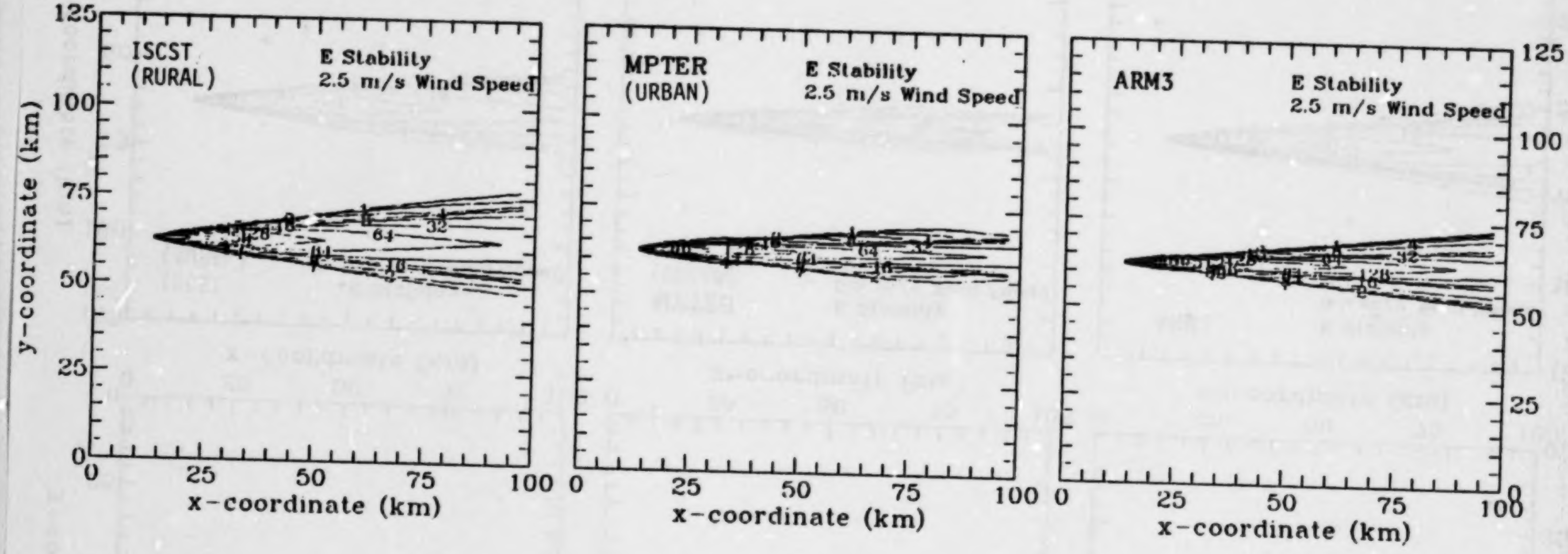


FIGURE B-3. Concentrations predictions ($\mu g/m^3$) by the ISCST and ARM3 under stable conditions (stability classes E and F). Emission rate = 1000 g/s.

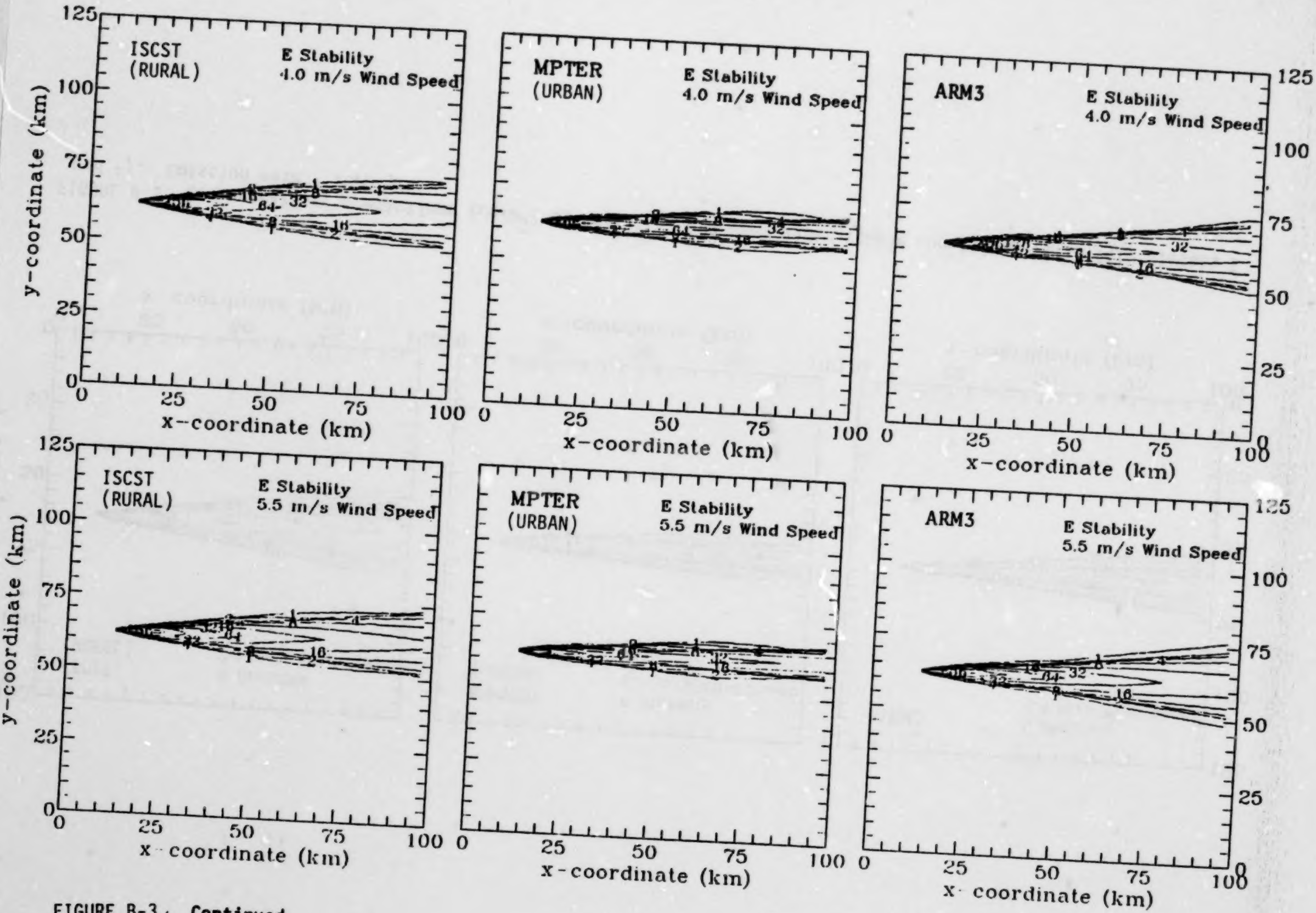


FIGURE B-3. Continued.

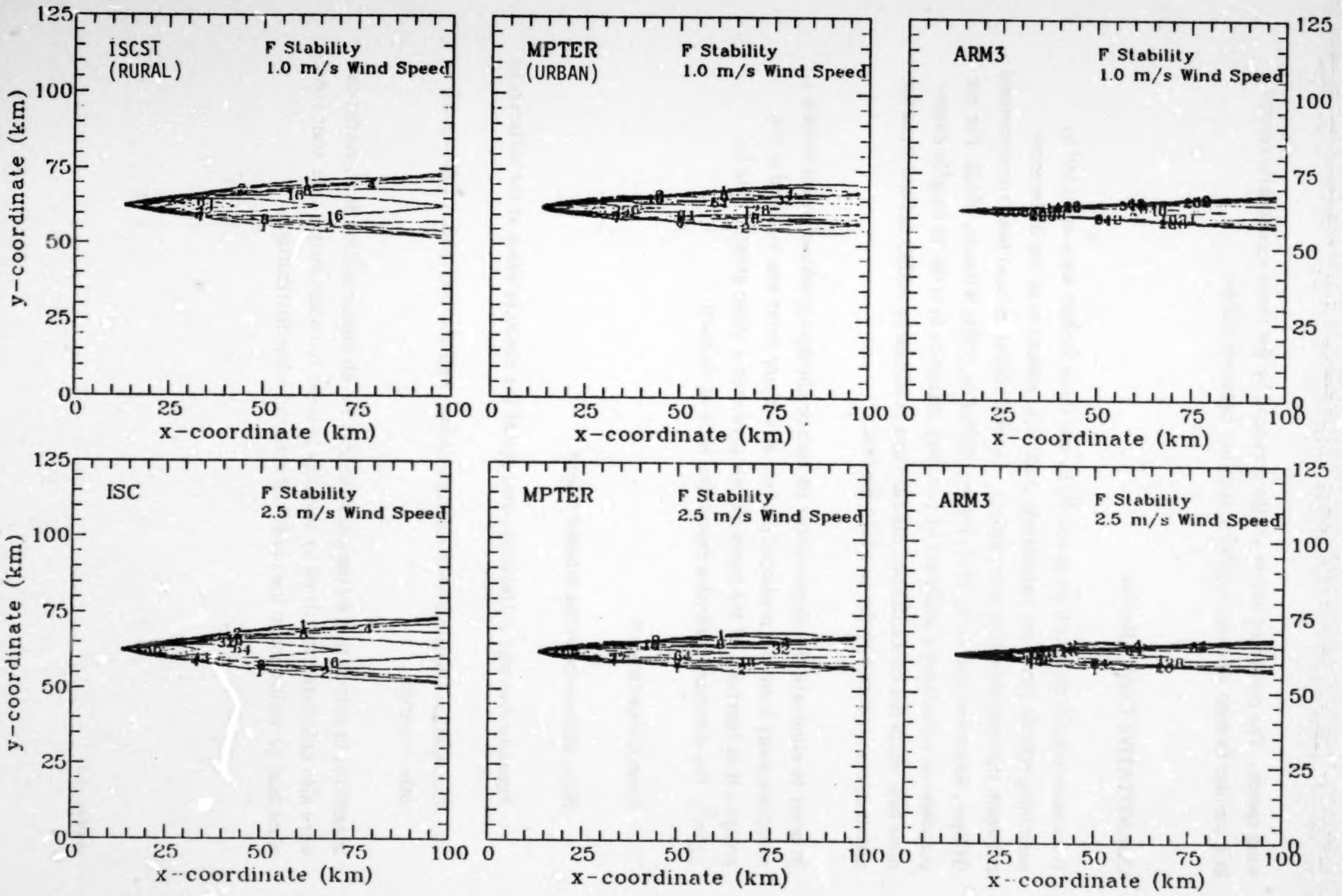


FIGURE B-3. Concluded.

wind speeds. The predicted plume widths produced by the three models also repond in a similiar fashion when atmospheric stability becomes stable.

QUANTITATIVE COMPARISON

The concentration distributions produced by the three models were analyzed by examining scatter plots and calculating statistical measures of the differences betweem the concentration distributions. Several statistics have been recommended (Hillyer, Reynolds, and Roth, 1979; Hayes, 1979; Fox, 1981; Wilmott, 1982). For our purposes we calculated a small set of summary statistics in order to roughly determine how much the concentration distributions produced by ARM3 deviate from the distributions produced by the two EPA models.

In order to eliminate the large number of zero predictions produced by all models at receptors away from the predicted plumes, a receptor point was included in the analysis if at least one of the three models predicted a value greater than 0.1 $\mu g/m^3$. The summary statistics calculated were as follows:

Mean Concentration

Bias--difference in the models' means

Absolute Average Difference--average of the absolute value of the differences

Correlation Coefficient--a measure of how well the two models follow each others trends.

In addition to calculating statistical measures for all concentration data, statistics were also calculated stratified by stability in order to obtain insight into what conditions lead to deviations in the predicted concentration distributions.

All Data

Figure B-4 compares the predictions produced by ARM3 with those produced by the ISCST and MPTER, as well as ISCST versus MPTER. The statistical measures of the differences between the three models are given in Table B-2. Suprisingly, the lowest bias and lowest absolute error between concentration distributions is between ARM3 and MPTER. The best correlation is between ARM3 and ISCST. Based on magnitude of differences and correlations, the two concentration distributions that are least like each other for all data are those produced by the two EPA-approved models, the ISCST and MPTER. It is encouraging that the mean concentration produced by ARM3 (218 $\mu g/m^3$) lies between the mean values of the ISCST (315 $\mu g/m^3$) and MPTER (195 $\mu g/m^3$).

Unstable Conditions

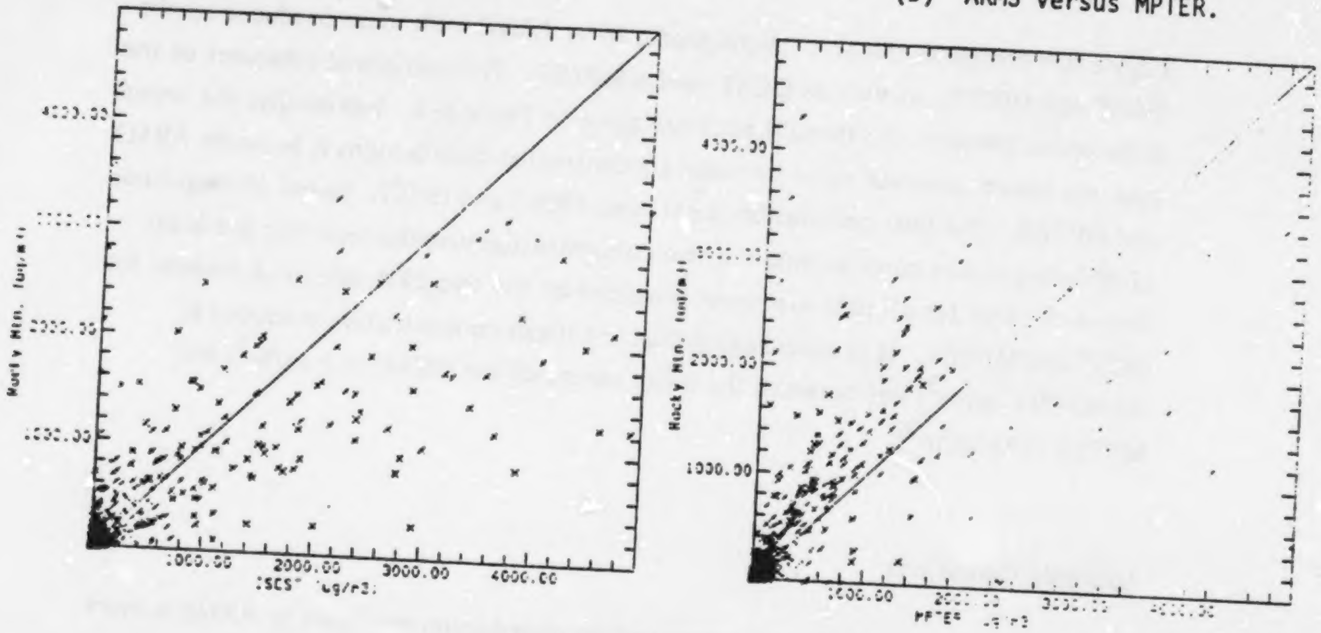
During unstable conditions the concentration distribution produced by ARM3 is more like the two EPA-approved models than the latter are like each other (Table B-2, Figure B-5). In fact, the correlation between predictions produced by ARM3 and MPTER models for unstable conditions is very high, 0.937. The fact that the magnitude of the bias and the absolute error between ARM3 and MPTER is about equal indicates that, in general, ARM3 systematically predicts slightly higher concentrations than MPTER under unstable conditions. This is also shown in the scatter plot in Figure 7b, which illustrates very good agreement between MPTER and ARM3.

Neutral Conditions

The comparison of predictions for neutral conditions is very similiar to the comparison of predictions for unstable conditions. The lowest bias and absolute error and highest correlation coefficient between concentration distributions are between ARM3 and MPTER. The concentration predictions of ARM3 and ISCST are next most similiar. The largest differences between model predictions are between MPTER and the ISCST (Table B-2, Figures B-6).

(a) ARM3 versus ISCST.

(b) ARM3 versus MPTER.



(c) MPTER versus ISCST.

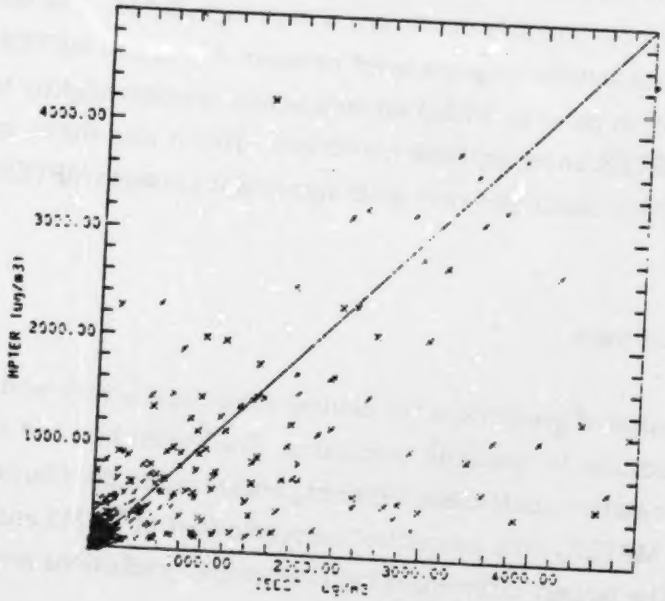
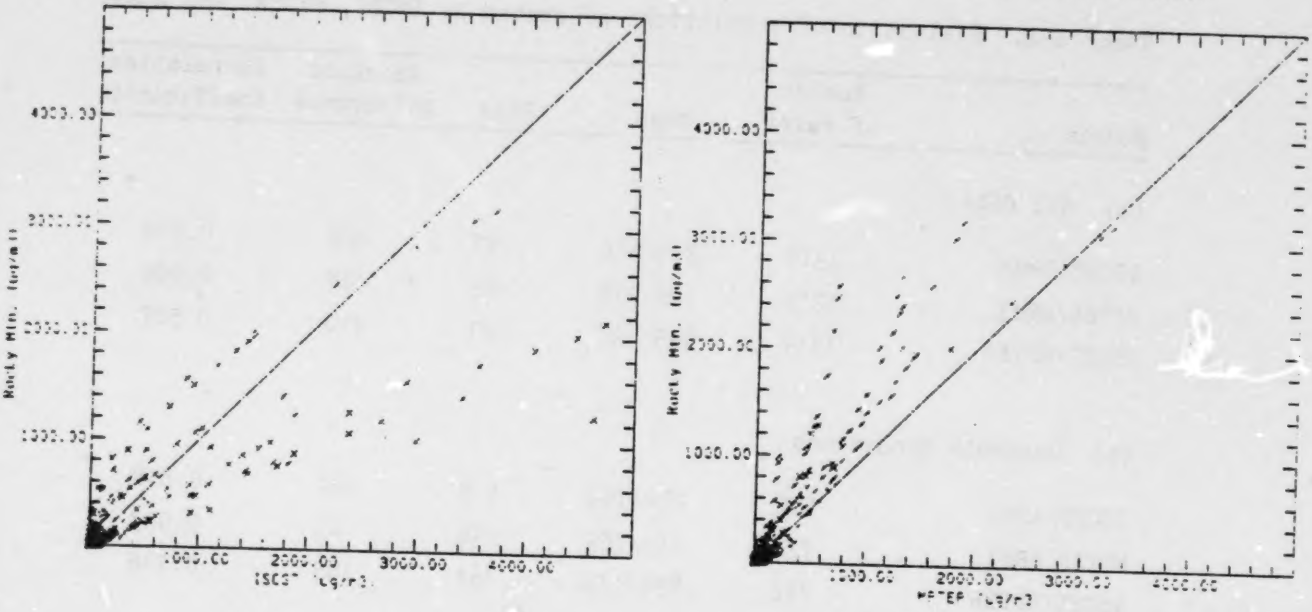


FIGURE B-4. Scatterplots of model predictions paired in time and space--all data.

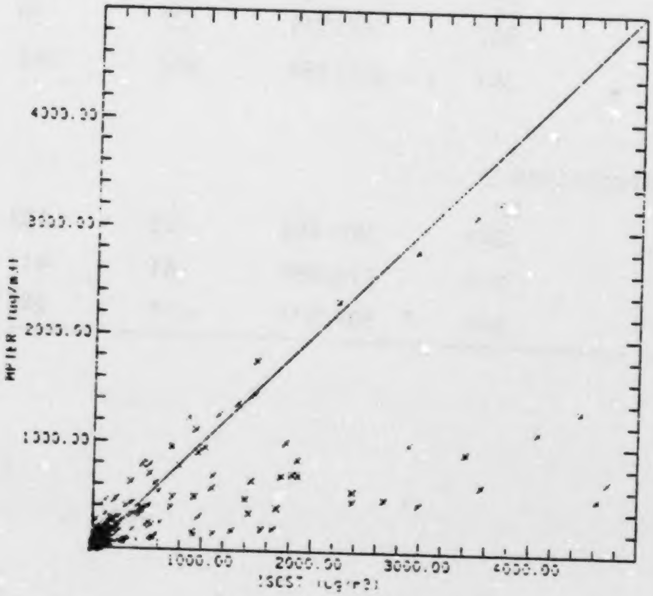
TABLE B-2. Evaluation of predictions generated by ISCST, MPTER, and ARM3.

Models	Number of Pairs	Mean	Bias	Absolute Difference	Correlation Coefficient
(a) All Data					
ISCST/ARM3	1319	315/218	97	208	0.698
MPTER/ARM3	1319	195/218	-23	128	0.690
ISCST/MPTER	1319	315/195	121	210	0.587
(b) Unstable Conditions					
ISCST/ARM3	772	274/159	115	162	0.858
MPTER/ARM3	772	113/159	-46	63	0.937
ISCST/MPTER	772	274/113	161	185	0.716
(c) Neutral Conditions					
ISCST/ARM3	307	356/176	180	264	0.762
MPTER/ARM3	307	154/176	-22	70	0.944
ISCST/MPTER	307	356/154	202	246	0.681
(d) Stable Conditions					
ISCST/ARM3	240	397/460	-63	282	0.618
MPTER/ARM3	240	511/460	51	411	0.536
ISCST/MPTER	240	397/511	-114	246	0.779



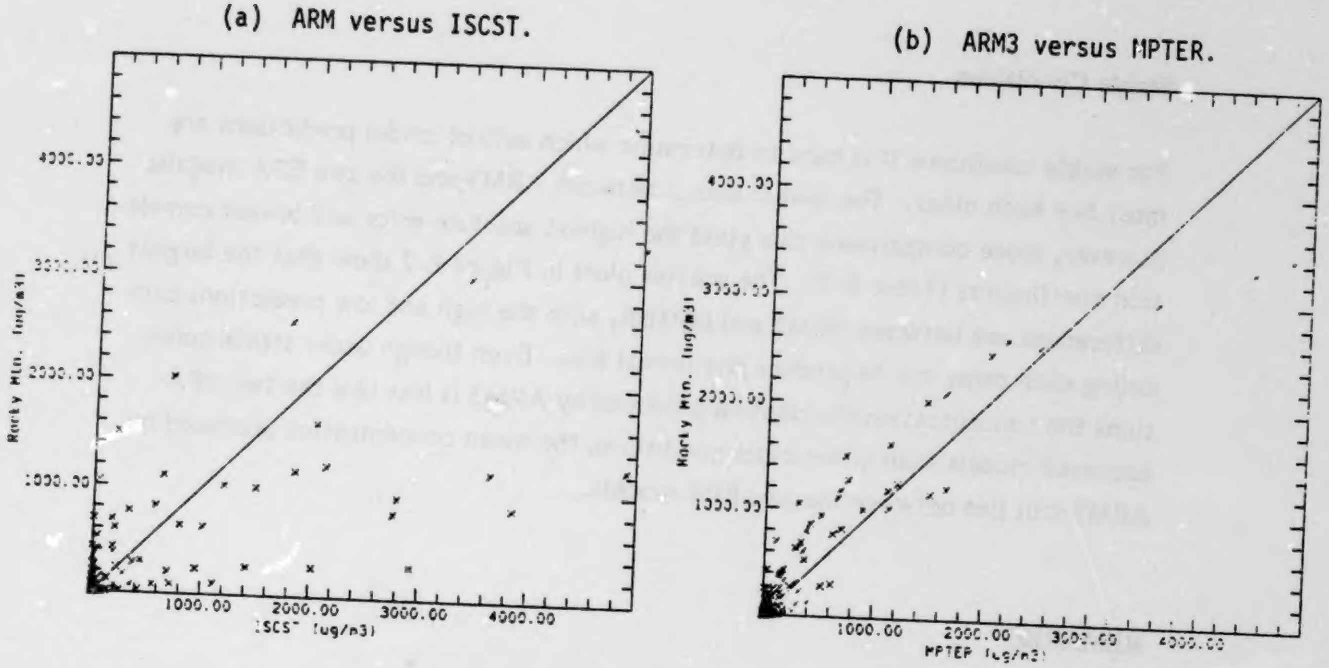
(a) ARM3 versus ISCST.

(b) ARM 3 versus MPTER.



(c) MPTER versus ISCST.

FIGURE B-5. Scatterplots of model predictions paired in time and space--unstable conditions only.



(a) ARM versus ISCST.

(b) ARM3 versus MPTER.

(c) MPTER versus ISCST.

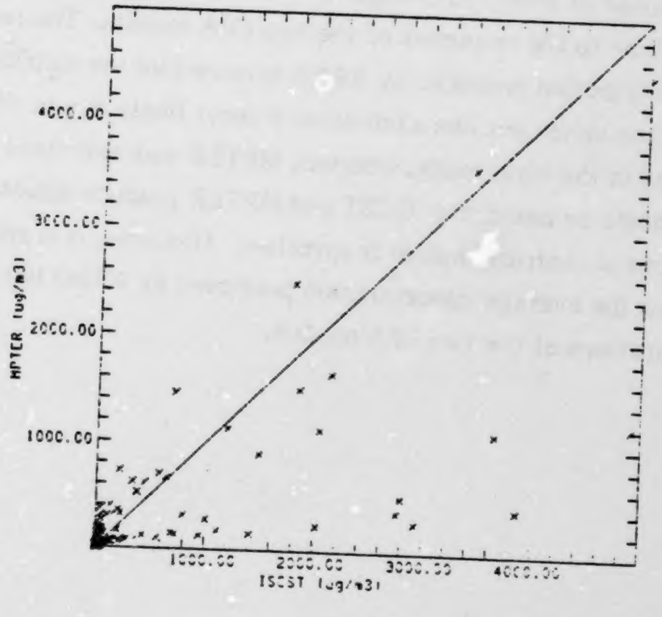


FIGURE B-6. Scatterplots of model predictions paired in time and space--neutral conditions only.

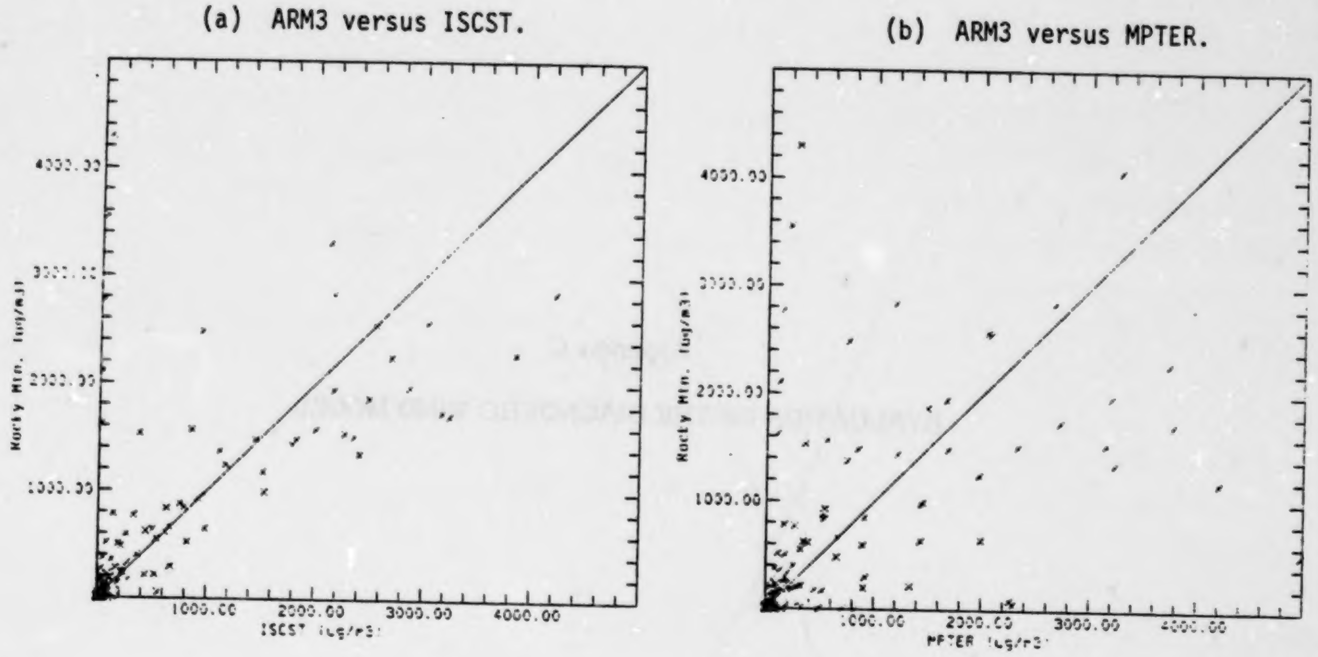
Stable Conditions

For stable conditions it is hard to determine which sets of model predictions are most like each other. The lowest bias is between ARM3 and the two EPA models; however, those comparisons also yield the highest absolute error and lowest correlation coefficients (Table B-2). The scatter plots in Figure B-7 show that the largest differences are between ARM3 and MPTER, with the high and low predictions canceling each other out to produce the lowest bias. Even though under stable conditions the concentration distribution produced by ARM3 is less like the two EPA-approved models than under other conditions, the mean concentration produced by ARM3 still lies between the two EPA models.

REMARKS

One of the major reasons for the differences in the concentrations calculated by ARM3 and the two EPA models in these simple tests is the fact that dispersion is parameterized in ARM3 in terms of time rather than downwind distance. Noting this, the response of ARM3 to changes in meteorological conditions is as expected and very similiar to the responses of the two EPA models. The result that the concentration distribution produced by ARM3 is more like the distributions of the EPA models than the latter are like each other is most likely due to the fact the ISCST was exercised in the rural mode, whereas, MPTER was exercised using the urban option. It should be noted that ISCST and MPTER produce almost identical results when the same urban/rural option is specified. However, it is encouraging that under all conditions the average concentration predicted by ARM3 lies between the average concentrations of the two EPA models.

116



(a) ARM3 versus ISCST.

(b) ARM3 versus MPTER.

(c) MPTER versus ISCST.

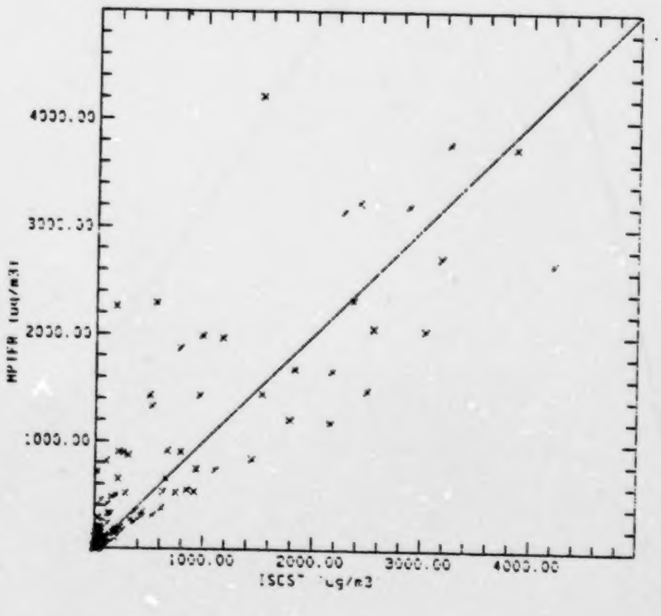


FIGURE B-7. Scatterplots of model predictions paired in time and space--stable conditions only.

87156

Appendix C

EVALUATION OF THE DIAGNOSTIC WIND MODEL

Under the sponsorship of the Minerals Managment Services (MMS) an in depth evaluation of the Diagnostic Wind Model (DWM) was performed. This model evaluation exercise included a detailed sensitity analysis as well as a comparison of the DWM wind fields with observations and with wind fields obtained from objective analysis techniques and from a primitive equation model. In this section we present part of the evaluation of the DWM which compares the DWM predictions to observations and compares wind fields created by the DWM using routinely available data alone and using routine and intensive observations. Further details of the sensitivity and evaluation of the DWM can be found in Kessler and Douglas (1988).

The evaluation of the DWM makes use of the 1985 South Central Coast Cooporative Aerometric Monitoring Program (SCCCAMP) intensive meteorological data base. Figure C-1 displays the South Central Coast Air Basin (SCCAB) where the SCCCAMP study took place. As seen in Figure C-1, the SCAB region contains regions of complex terrain, ocean, and the ocean-land interface. An evaluation of the DWM for this region, where land-sea and complex terrain air flows dominate, is a particularly stringent test. The 1985 SCCCAMP study consisted of four intensive measurement preiods: (1) 12-14 September, (2) 20-21 September, (3) 23-25 September, and (4) 2-4 October. During the 1985 SCCAMP intensive monitoring period there were over 75 surface meteorological monitoring sites (Table C-1) and 14 upper-air observation sites (Table C-2) in operation. As seen in Figure C-2 and C-3 most of these sites are concentrated along the coast or within the urban areas of Ventura County (the eastern portion of the SCCAB domain).

Three different methods are used to evaluate the Diagnostic Wind Model (DWM) wind fields. First, the wind fields produced by the DWM are compared to aircraft obser-

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TABLE C-1. SCCCAMP surface monitoring stations. UTM coordinates are in zone 11.

Station ID	Station	UTM_E	UTM_N
ANCP	Anacapa Island	275.6	3765.7
ANNE*	Annie	235.5	3817.5
B46A	Buoy 46A (46011)	146.2	3865.3
B46M	Buoy 46M (46023)	159.4	3801.4
B460	Buoy 460 (46025)	305.4	3730.7
BTLS	Battles	189.4	3869.3
BURB	Burbank	373.8	3786.3
BUYF	Buoy F	213.6	3794.1
BUYG	Buoy G	303.2	3762.9
CARC	Carpinteria	270.2	3810.3
CHUC*	Chuchu	317.0	3852.5
CMRL	Camarillo	311.1	3787.1
CSPK	Castro Peak	335.8	3772.3
ECPB	El Captitan Beach	222.6	3817.1
ELWT	Ellwood	230.7	3812.4
FIGO*	Figueroa	225.2	3843.7
EXNC	Exxon C	220.8	3819.4
GAVE	Gaviota	205.1	3818.8
GAVP	Gaviota	206.1	3818.7
GLTA	Goleta	239.1	3816.6
GOVP	Government Point	185.8	3817.2
GVPS	Gaviota Pass	204.3	3822.1
HWTN	Hawthorne	377.0	3753.9
LANC	Lancaster	388.3	3843.6
LANG	Los Angeles	370.6	3756.2
LCMP	LaCumbre Peak	249.3	3820.8
LGPK	Laguna Peak	310.0	3776.1
LGPP	Laguna Peak	309.1	3776.1
LMPC	Lompoc (Vandenberg)	173.2	3850.9
LMPH	Lompoc (H.S. and P)	185.9	3848.3
LMPJ	Lompoc (Jalama Rd.)	186.0	3824.9
LMPS	Lompoc (S. H. St.)	182.8	3838.8
LNBH	Long Beach	393.6	3742.6
MLBU	Malibu	344.9	3767.7
MLNO	Molino	212.5	3819.6
NBPK	Newbury Park	324.9	3783.6

(continued)

TABLE C-1. Continued.

Station ID	Station	UTM_E	UTM_N
OFLP	Oak Flats	325.5	3813.5
OJMH	Ojai (Maricopa Hwy.)	291.5	3814.2
OSTW**	Onshore Tower	271.2	3807.7
OXNR	Oxnard	297.3	3786.3
OZNA*	Ozena	280.2	3842.2
PHNM	Port Huneme	296.2	3780.8
PIR2	Piru (2SW)	332.7	3807.8
PLGN	Platform Gina	289.7	3777.6
PLGR	Platform Grace	272.4	3784.7
PLTH	Platform Hondo	213.1	3808.5
PLTZ**	Platform Hazel	263.6	3807.7
PRTO*	Prieto	248.3	3824.1
PTAG	Pt. Arguello	165.1	3831.2
PTDM	Pt. Dume	332.6	3764.6
PTM1	Pt. Mugu	303.5	3776.2
SBRA	Santa Barbara	239.0	3813.3
SCRZ	Santa Cruz Island	256.2	3765.4
SIMC	Sima Valley (Cochran)	345.4	3794.3
SLBP	San Luis Obispo	167.8	3904.5
SMCP	San Marcos Pass	241.4	3821.0
SMGP	San Miguel Island	190.7	3772.6
SMIL	San Miguel Island	188.9	3771.5
SMON	Santa Monica	366.1	3765.1
SMRA	Santa Maria	184.7	3867.2
SMRB	Santa Maria (Briarwood)	181.9	3866.2
SMRG	Santa Maria (Glacier Lane)	191.0	3863.6
SMTN	South Mountain	314.2	3800.4
SNIC	San Nicolas Island	271.7	3679.3
SNIL	San Nicolas Island	267.0	3679.4
SPLA	Santa Paula	312.5	3810.4
SPLP	Santa Paula	309.6	3802.7
SYNZ	Santa Ynez	217.6	3834.0
TMSC*	Temesc	334.7	3818.9
TORN	Torrence	376.9	3740.6

(continued)

TABLE C-1. Concluded.

Station ID	Station	UTM_E	UTM_N
TTHS**	Tethersonde	269.0	3807.0
VANH	Vandenberg (Herado Ave)	176.7	3848.6
VANW	Vandenberg (Watt Rd)	170.5	3854.4
VENE	Ventura (Emma Woods)	286.4	3795.4
VNUY	Van Nuys	363.7	3787.3
WDSM	Wadstrom	287.5	3802.1
WLDG	White Ledge	304.4	3818.4

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* U.S. Forest Service station reporting once per day. (Location not plotted.)

** API station reporting for limited periods only. (Location not plotted.)

TABLE C-2. SCCCAMP upper-air monitoring stations. UTM coordinates are in zone 11.

Station ID	Station	UTM_E	UTM_N
CYMA	Cuyama	244.5	3870.0
GAVO	Gaviota	204.2	3818.8
LCMB	LaCumbre	253.8	3816.2
LMPC	Lompoc (Vandenberg)	173.2	3850.9
LOYL	Loyola	368.8	3759.5
OFLT	Oak Flats	324.6	3815.7
PLGN	Platform Gina	289.7	3777.6
PLTC	Platform C	258.0	3801.7
PTD1	Pt. Dume	333.8	3764.5
PTM1	Pt. Mugu	303.5	3776.2
PTM2	Pt. Mugu	304.5	3777.3
SMIG	San Miguel Island	192.6	3772.5
SNIR	San Nicolas Island	269.0	3683.8
SSUS	Santa Susana	346.2	3790.9

vations. Second, the diagnostic wind model is exercised using only routinely available observations; the wind fields generated both with and without the supplementary observations available during the 1985 SCCCAMP monitoring period are compared. Third, the wind fields generated using the diagnostic wind model are compared with dual-Doppler-radar derived winds.

COMPARISON OF WIND FIELDS AND AIRCRAFT DATA

Meteorological data from the aircraft operated by the Research Aviation Facility of the National Center for Atmospheric Research (NCAR) are available for each of the intensive measurement periods. A total of 16 flights spanning approximately 28 hours were made during the field program. Wind speed and wind direction were measured every second along the aircraft flight path. The flight patterns consisted of spirals and/or constant altitude traverses.

In this section, the meteorological aircraft data from two flights made on 23 September 1985 are compared with the corresponding analyzed wind fields and then included as input in the diagnostic wind model.

Flight No. 1 on 23 September spanned the period 12:02:39 to 13:04:18 PDT. Data for this flight were archived at 5-second intervals. The horizontal flight pattern and a vertical cross section of the flight pattern are shown in Figure C-4.* The aircraft began measuring data between Camarillo and Port Huneme; it followed a northeastward course until reversing its direction just northeast of Piru; it flew westward and then southwestward to the eastern end of Santa Cruz Island, and then returned to Camarillo. During this time the altitude varied between 0 and 900 m.

The data were horizontally averaged within 5-km grid squares, vertically averaged within the model layers, and then assigned to the hour nearest the observation time. Figure C-5 (a and b, d and e, g and h, and j and k) and C-6 (a and b, d and e, and g and

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* For the convenience of the reader, all figures appear at the end of this section.

134

h) present the averaged aircraft data and the diagnostic-wind-model wind fields for layers 2-5 at 1200 and layers 2-4 at 1300 PDT on 23 September, respectively. Note that the aircraft data are plotted at the average locations rather than the grid cell centers. Nonaircraft observations are plotted as well. No aircraft data were applicable to layer 1 (10 m). At 1200 PDT, there is good agreement between the analyzed wind field and the aircraft observations. In layer 2 (100 m) (Figures C-5a and C-5b), the aircraft observations agree with the westerly flow analyzed over the Oxnard Plain. In layer 3 (300 m) (Figures C-5d and C-5e), the southwesterly flow along the flight pattern is directionally consistent with, but significantly faster than, the analyzed wind field. Agreement is not as good in layer 4 (600 m) (Figures C-5g and C-5h), with only two of the averaged aircraft observations indicating southerly flow. In layer 5 (1000 m) (Figures C-5j and C-5k), southerly flow is apparent in both the aircraft observations and the analyzed wind field.

At 1300 PDT, the layer 2 aircraft observations reflect the northwesterly along-shore flow that is apparent in the analysis (Figures C-6a and C-6b). In layer 3 (Figures C-6d and C-6e), observations taken during two different segments of the flight exhibit some disagreement with the analyzed wind field and with each other. The northwesterly layer 4 observations disagree significantly with the southerly winds in the analyzed wind field (Figures C-6g and C-6h). No observations are assigned to layer 5 at 1300 PDT.

Although agreement between aircraft data and the analyzed wind fields is generally good, there are some discrepancies. Note that wind data taken during spirals and other ascents/descents may not be reliable. In general, including the aircraft observations in the input data set for the diagnostic wind model did not alter the analyzed wind fields dramatically. The newly generated wind fields are presented in Figures C-5 (c, f, i, and l) and C-6 (c, f, and i) for 1200 and 1300 PDT, respectively. The most significant differences occur in layers 3 and 4 at 1300 PDT (Figures C-6f and C-6i). The mean absolute differences for the two analyzed wind fields averaged over all grid points nearest to where the aircraft data were inserted are given in Table C-3. The mean absolute differences for both the u and v wind components are less than 2 m s^{-1}.

125

TABLE C-3. Mean absolute differences for simulations with and without aircraft data.

	u (m s^{-1})	v (m s^{-1})
Flight No. 1	1.60	1.24
Flight No. 2	2.50	0.93
Flights 1 and 2 combined	1.98	1.11

Flight No. 2 on 23 September began at 20:14:53 PDT and ended at 20:51:37 PDT. Data were archived at one-second intervals for this flight. The horizontal and vertical flight patterns are illustrated in Figure C-7. This flight covered a smaller area between Camarillo and Santa Cruz Island than did Flight No. 1. However, the vertical extent was greater, with deep soundings extending to 1900 m.

The data were again averaged both horizontally and vertically and assigned to the nearest hour. Plots of the data at 2000 and 2100 PDT are shown in Figures C-8 and C-9 (a, d, g, j, and m). The figure also compares these data with the analyzed wind fields from the diagnostic wind model at these times (Figures C-8 and C-8b, e, h, k, and n). At 2000 PDT, the layer 1 aircraft observations show a more easterly component than do the analyzed winds (Figures C-8a and C-8b). The same is true in layer 2 (Figures C-8d and C-8e). Layers 3, 4, and 5 (Figures C-8g, C-8h, C-8j, C-8k, C-8m, and C-8n), however, show good agreement.

The 2100 PDT aircraft observations also compare favorably with the analyzed wind fields. The single observation in layer 1 is not inconsistent with the layer 1 analyzed wind field (Figures C-9a and C-9b). In layer 2, the west-northwesterly offshore flow and the northeasterly flow over the Oxnard Plain both agree with the direction of the analyzed winds but have larger magnitudes than their analyzed counterparts (Figures C-9d and 5-9e). In layer 3 (Figures C-9g and C-9h), a discrepancy exists between the northwesterly aircraft observation inland of Pt. Mugu and the northerly analyzed flow in this region. Over the channel the directions agree, but the magnitudes associated with the aircraft observations are much larger than the analyzed field values. There is good agreement in layer 4 (Figures C-9j and C-9k), but there is disagreement in both magnitude and direction in layer 5 (Figures C-9m and C-9n).

The aircraft data are incorporated into the diagnostic wind fields for 2000 and 2100 PDT on 23 September, and the newly analyzed fields are presented in Figures C-8 and C-9 (c, f, i, l, and o). In this case the mean absolute difference for the u component is 2.5 m s^{-1}. This relatively large value is probably due to the large magnitude of the aircraft observations in the vicinity of Anacapa Island in layers 2 and 3 at 2100 PDT. The differences for Flight No. 2, as well as the mean absolute differences for both flights combined, are given in Table C-3.

The relatively small changes introduced into the analyzed wind fields by the aircraft data indicate that (1) nonaircraft observations in the flight regions are generally sufficient to resolve the important airflow characteristics, and (2) the objective-analysis procedure is reasonably successful in using the available information to provide winds at those grid points within the flight region where no data are available. Aircraft data do, however, introduce additional information in regions where data are sparse. This is especially apparent at 2100 PDT in layer 5 (Figure C-9m,n,o), where aircraft observations in the eastern channel introduce northeasterly winds, whereas the objective analysis originally produced southeasterly winds. Additionally, the aircraft data indicate small-scale variability (even at upper levels) that cannot be resolved by the nonaircraft data network. Disagreement between aircraft observations and other observations (i.e., at 1200 PDT in layer 4), however, raises questions about the reliability of the aircraft data and especially the averaging procedures.

COMPARISON WITH WIND FIELDS USING ONLY ROUTINE DATA

One way to determine whether the diagnostic wind model is providing an accurate depiction of the wind field in data-sparse areas is to regenerate the wind fields using a subset of the data. The omitted data can then be used as independent verification for the model. In this study, the wind fields for 23 September 1985 were regenerated using only those observations that are routinely available in the SCCCAMP region. The routine stations listed in Table C-1 and C-2 and consist of both surface (aerometric and meteorological) and upper-air (radiosonde) stations. Note that only those stations that reported data on 23 September 1985 are listed here. This approach to evaluating the diagnostic wind model also provides us with a means of assessing the utility of the routine data network and estimating the level of enhancement that is provided by the supplementary data taken during the SCCCAMP monitoring program.

Two experiments were performed using the routine data (RTN1 and RTN2). The purpose of the first experiment was to evaluate the performance of the diagnostic wind model in data-sparse areas; the wind fields generated using only routine data were compared with the supplementary observations. This experiment was identical to the original simulation except for the omission of the supplementary observations in RTN1.

The purpose of the second experiment was to evaluate the routine monitoring network through comparison of analyses generated both with and without the supplementary data. In this experiment, the controlling parameters for the diagnostic wind model were respecified to generate the best possible wind fields using only the routine data.

In the first test of the diagnostic wind model using only routine data (RTN1), the controlling model parameters were unchanged from those of the previous simulation. To provide a direct comparison between wind fields generated both with and without the SCCCAMP supplementary observations, any observations that were rejected from the original experiment during the data-checking procedure were excluded from this experiment as well. This occurred primarily at the Pt. Mugu station, where radiosonde data were rejected in favor of Doppler data at times very distant from radiosonde launch times.

Sample observation plots illustrating the locations of the routine stations for layers 1 and 2 are given in Figure C-10 for 0000 PDT on 23 September 1985. At the surface the routine data network is less dense along the coast and lacks observations in the channel and in the inland areas near Santa Paula, Santa Ynez, and Cuyama. Aloft, there are only two routine observing stations in the SCCCAMP domain, and they are located at Pt. Mugu and Vandenberg. Other upper-air stations are located outside the domain.

In the following discussion, the diagnostic wind model fields generated using only routine data in RTN1 are compared with the supplementary observations. Three-hourly plots of the RTN1 surface wind fields are presented in Figure C-8, together with the corresponding observation plots, which include both routine and supplementary data. The RTN1 wind fields can also be compared to the original diagnostic-wind-model wind fields that incorporated both routine and supplementary data. These are presented at three-hour intervals in Figure C-11. Qualitative evaluation of the diagnostic wind model focuses on the following coastal and inland areas that were supplemented with non-routine data: (1) Santa Ynez, (2) Oxnard Plain, (3) Pt. Dume, (4) Santa Clara River Valley (White Ledge/Santa Paula), and (5) Cuyama. The 23 September simulation is divided into four 6-hour time periods. Surface and upper-air features are discussed separately.

Southerly flow observed in the Santa Ynez region between 0000 and 0200 PDT is not depicted by the diagnostic wind model in RTN1, which shows northeasterly/downslope flow in this region. The RTN1 simulations in this area improve between 0300 and 0600 PDT as the observed wind shifts to a northeasterly direction in agreement with the simulated slope flows. The Pt. Dume area winds are depicted satisfactorily during the 0000 to 0600 PDT period. The calm winds observed over the Oxnard Plain between 0000 and 0300 PDT are replaced in the RTN1 field by the moderate, northeasterly domain-mean wind specified during this period. Between 0400 and 0500 PDT (not shown), however, there is good agreement in this area. Downslope flows near Santa Paula agree with the direction of observed winds, but the magnitudes are larger than those of the observed winds. Although the domain-mean wind is based on the Cuyama sounding, the magnitude of the wind is larger than that of the observed surface wind at this station. A deceleration of the domain-mean wind in the Cuyama Valley in RTN1 is in agreement with the observations.

Between 0600 and 0900, the observed winds in the Santa Ynez area continue to be represented in RTN1. However, observed south-southwesterly winds in this area between 1000 and 1200 PDT are not depicted. Sea-breeze penetration across the Oxnard Plain between 0600 and 1200 PDT is limited by the northeasterly domain-mean wind. Winds inland of Pt. Dume reflect the domain-mean wind and disagree with the observations during this period, but the influence of Loyola (located outside of the domain) on the offshore analysis indirectly improves the RTN1 field in this area. Downslope flow near Santa Paula persists in the model after upslope flow is observed. Toward the end of this period, upslope flows develop, but the magnitudes are much less than those observed in the Santa Paula/White Ledge area due to an opposing mean flow. At Cuyama, the RTN1 wind speeds are somewhat higher than the observed wind speeds.

Between 1200 and 1800 PDT, the southwesterly flow near Santa Ynez is replaced by a somewhat modified, northwesterly domain-mean wind. Sea-breeze penetration in the Oxnard Plain continues to be restricted, but the modeled field improves as the domain-mean wind veers to north-northwest after 1400 PDT. Winds in the Pt. Dume area are in reasonable agreement with supplementary observations during this period. Near White Ledge and Santa Paula, superposition of the slope flows on the domain-mean wind in the diagnostic wind model causes the primary analyzed upslope flow component to be directionally inconsistent with the observations in this region. This is partly because the domain-mean wind does not reflect the onshore flow through the Santa Clara River Valley. With a north-northwest domain-mean wind, the observed decrease of the wind at Cuyama is not achieved in RTN1.

Conditions similar to those occurring during the previous 6-hour period persist at Santa Ynez until 2100. Offshore flow over the Oxnard Plain beginning at approximately 2000 PDT is depicted in RTN1; however, RTN1 wind speeds exceed the values observed there. Winds in the Pt. Dume area generally resemble the observations between 1800 and 2300 PDT. Downslope flow in the Santa Paula area develops later in the model wind fields than in the observed data. Again, the wind speeds at Cuyama are somewhat higher than the observed wind speeds.

Surface difference fields (both component differences and vector differences) illustrate the differences between the original diagnostic wind model field for 23 September and RTN1. These are plotted in Figure C-9 at three-hour intervals. Large differences in inland areas indicate that the diagnostic wind model is unable to reproduce the supplementary observations in these areas. In addition to differences (large at times) in the areas just discussed, there are also large differences along the northern Ventura coastline between 1200 and 1800 PDT. These discrepancies indicate very localized flow near the supplementary monitoring station at Wadstrom that neighboring stations at Emma Woods, Ojai, and Carpinteria cannot resolve. Mean absolute differences between RTN1 and all land-based supplementary observations for the 24-hour period are 1.63 m s^{-1} for the u-component and 1.71 m s^{-1} for the v-component.

The ability of the diagnostic wind model to simulate airflow aloft is a function of data availability and is therefore severely limited by the lack of upper-air observing stations in the routine data network. The layer 3 (300 m) RTN1 wind field for 1200 PDT 23 September is compared in Figure C-10 with the corresponding diagnostic wind field that incorporated the supplementary observations. Available observations are represented in the RTN1 field; elsewhere, the domain-mean wind dominates. Recall that the domain-mean wind is based upon the Cuyama sounding.

The second test in which only routine data were incorporated into the diagnostic wind model (RTN2) was performed to evaluate the ability of the routine data network to resolve the important airflow features of the SCCCAMP region relative to the enhanced monitoring network. For this experiment, all of the routine data were used, regardless of whether they were retained in the original data set. The controlling parameters for the diagnostic wind model that depend on the data density were respecified as R_{max} (the maximum radius of influence) = 20 km at the surface over land, 100 km aloft over land, and 200 km in all layers over water; R (the relative weighting parameter) = 10 km at the surface and 75 km aloft; and K_{max} (the number of interpolating stations) = 3 at the surface and 2 aloft. These are listed in Table C-4. The diagnostic wind model was again exercised for 23 September 1985. In the following discussion, the RTN2 wind fields are compared with the original diagnostic-wind-model fields for this date. Three-hour-interval plots for each of these simulations are given in Figure C-11. Qualitative evaluation of the routine data network focuses on the following areas: (1) the Santa Barbara Channel, (2) Pt. Dume area, (3) the Oxnard Plain, and (4) the Santa Clara River Valley. Again the discussion is divided into four 6-hour periods.

131

TABLE C-4. Controlling parameters used in the diagnostic wind model for RTN2.

Parameter	Location	Value
R_{max} (km)	Surface, Land	20
	Aloft, Land	100
	Water	200
R (km)	Surface	10
	Aloft	75
K_{max}	Surface	3
	Aloft	2

Major differences are observed in the channel during the period 0000 to 0600 PDT due to the absence of Buoy F, Platform C, and the intermittent Acania data. The routine data network is not sufficient to resolve the "Gaviota eddy" and associated convergence zones that exist in the channel between 0000 and 0300 PDT. The San Miguel Island observation is needed to define the flow at the southern end of the channel. There is a routine observing station located on the island; however, no data from this station were included in the SCCCAMP data archive for 23 September. The convergence zone located southwest of Pt. Dume during this period is not so well defined in the routine data experiment. The calm area in the Oxnard Plain from 0000 to 0300 PDT, which is depicted in the original diagnostic-wind-model field, is not represented in RTN2, but the northeasterly flow between 0400 and 0500 is represented. Drainage flow from the Santa Clara River Valley is stronger in RTN2.

Northwesterly winds at Buoy 46M, supplementary observations in the channel, and upslope flow along the Santa Barbara coastline define the "Gaviota eddy" in the original diagnostic wind fields beginning at 0800 PDT. Without the channel observations, this eddy is not as clearly defined in the routine data experiment. Winds off the coast of Pt. Dume are depicted reasonably well in RTN2 between 0600 and 1200 PDT. Depiction of the onset of the sea breeze and the extent of the sea-breeze penetration during this period is limited in RTN2 by the lack of observations in the Oxnard Plain and the Santa Clara River Valley.

The persistence of cyclonically curved flow in the channel from 1200 to 1800 PDT is not clearly depicted in RTN2. Buoy F appears to be critical in defining this circulation. Land-based stations exert an extraordinary amount of influence on the flow in the channel in the routine data experiment. San Nicolas Island must be closely coupled with San Miguel Island during this period, since San Miguel Island observations are nearly reproduced. Airflow south of Pt. Dume is again in reasonable agreement with the supplementary observations, probably due to the influence of the Loyola station in this region. Sea-breeze penetration in the Oxnard Plain and Santa Clara River Valley continues to be restricted, but depiction of the airflow in that area in RTN2 improves after 1400 PDT, when the domain-mean wind shifts to reinforce this flow.

Large differences are exhibited over the channel between 1800 and 2300 PDT. A potential mid-channel eddy circulation at 2100 PDT is not as clearly resolved in the routine data experiment. Again, the convergence zone southwest of Pt. Dume is weaker than in the original diagnostic-wind-model field. As drainage flow develops in the Santa Clara River Valley, wind directions in this area agree; however, the influence of the domain-mean wind in the routine data experiment produces larger wind speeds in RTN2.

The layer 3 (300m) RTN2 wind field is given in Figure C-12 for 1200 PDT 23 September. This can be compared with the upper-air fields in Figure C-10. The routine upper-air-data network is insufficient both spatially and temporally to resolve mesoscale upper-air features with periods of less than 12 hours. Under certain circumstances, synoptic-scale features may be represented (especially at higher levels, where less variability in the flow pattern is expected). The SCCCAMP monitoring network, which includes 9 Doppler acoustic sounders located throughout the domain (with observations at half-hour intervals) and two additional radiosonde stations at Cuyama and on the research vessel Acania (a moving station), provides much improved spatial and temporal resolution.

COMPARISON WITH WINDS DERIVED FROM THE DUAL-DOPPLER RADAR MEASUREMENTS

Two NOAA/Wave Propagation Laboratory 3-cm wavelength (X-band) pulsed Doppler radar, located at Gaviota and Santa Barbara, were used during the SCCCAMP to observe the two-dimensional airflow in the marine boundary layer over the central and western portions of the Santa Barbara Channel (Kropfli, 1986). Dual-Doppler radar measurements are available for each of the SCCCAMP intensive measurement periods. The dual-Doppler radar derived wind fields represent the vertically averaged horizontal wind fields within the marine boundary layer. Features with horizontal wavelengths greater than 10 km are preserved. Hourly composites of the horizontal wind fields were produced from the individual scans taken at 5 to 10 minute intervals.

In this section, the hourly averaged wind fields derived from the dual-Doppler radar measurements are qualitatively compared for 23 September (at 0900, 1000, 1100, 1900, 2000, 2100 PDT) with the surface-layer wind fields generated using the diagnostic wind model. In the dual-Doppler-radar derived wind fields certain features should be viewed with suspicion (Kropfli, 1986). These include (1) features with wavelengths smaller than 15 km, (2) features that appear on only two successive plots and (3) features which create unrealistic convergence or divergence zones. The surface-layer wind analyses and the dual-Doppler-radar derived winds for the six hourly periods on 23 September are presented in Figure C-13.

Dual-Doppler-radar derived winds in the Santa Barbara Channel are generally light and westerly during the period from 0900 to 1100 PDT (Figures C-13b,d, and f). The magnitude of the westerly wind component increases from north to south. Slight cyclonic curvature is observed in the flow patterns.

At 0900 PDT the analyzed surface-layer winds within the western and central Channel are light and westerly (Figure C-13a). In the northwestern portion of the area covered by the dual-Doppler-radar grid, the analyzed winds have a southerly component while the radar-derived winds have a northerly component (Figure C-13b).

There is an overall increase in wind speed in both the analyzed field and the radar-derived wind field by 1000 PDT (Figures C-13c and d). Westerly flow is maintained in both fields. Analyzed winds in the northern part of the dual-Doppler-radar grid develop a southerly component as onshore flow develops along the coast (coastal observations influence the objective analysis in the Channel). This is only slightly apparent in the radar-derived wind field. There is good agreement between the two fields in the southern half of the dual-Doppler-radar domain. Both show a west-to-east transition from northwesterly to westerly flow.

At 1100 PDT, westerly flow with some amount of cyclonic curvature is maintained in both the analyzed field and the radar-derived wind field (Figures C-13e and f). A southerly component in the analyzed field in the northern and eastern portions of the dual-Doppler-radar domain is a result of the influence on the analysis in the Channel of coastal onshore/upslope flow observations. Except for a slight southerly component to the flow in the northeastern corner of the grid, this is not represented in the Doppler-radar-derived winds. In the remainder of the domain, there is good agreement between the two fields.

Between 1850 and 2050 PDT, the dual-Doppler-radar derived wind fields are characterized by relatively strong (6 m s^{-1}) northwesterly winds (Figures C-13h, j and l). The cyclonic curvature of the flow increases during this period and an offshore flow component can be observed in the northernmost portion of the grid at 1950 and 2050 PDT.

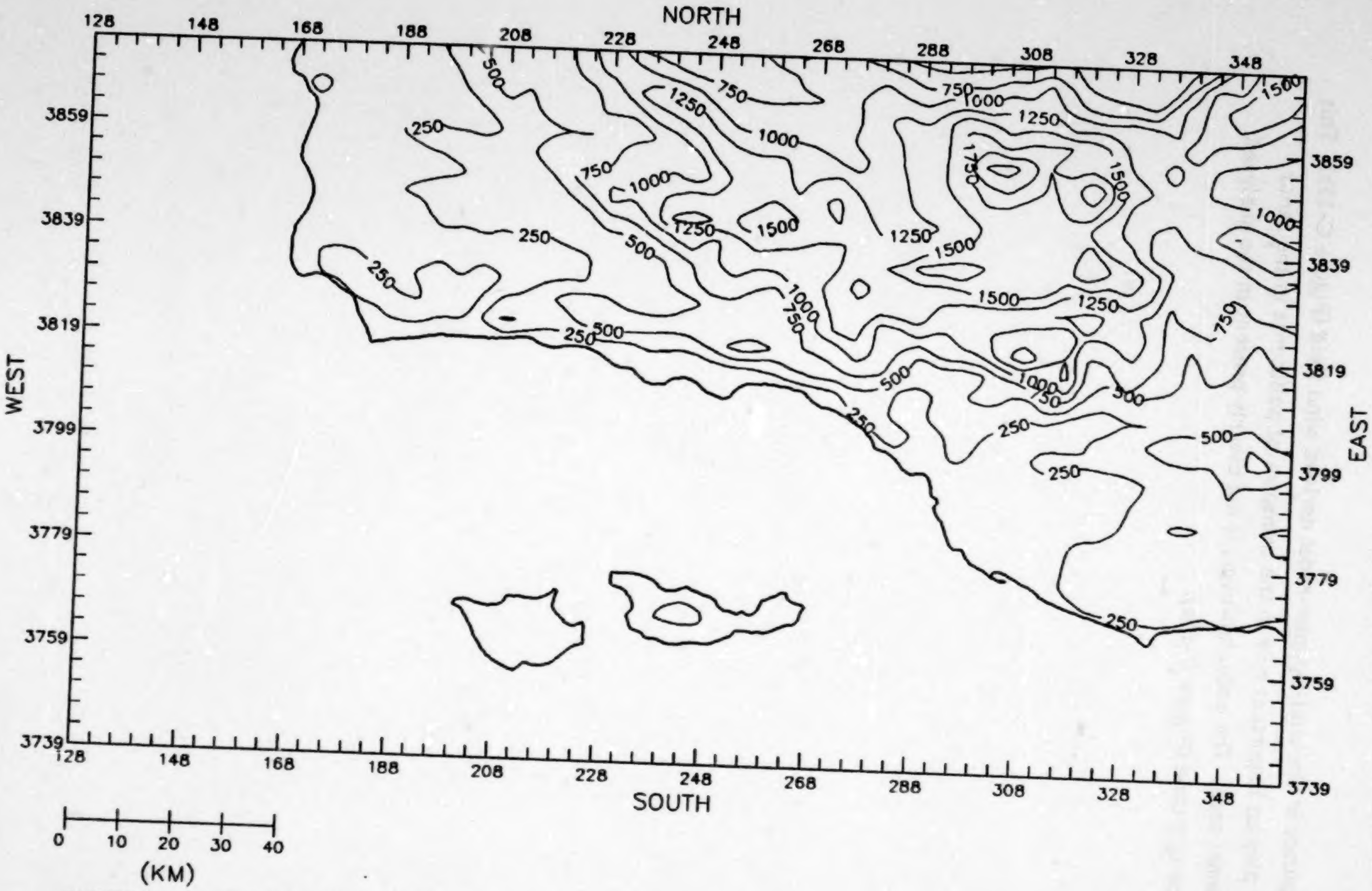
A comparison of the analyzed surface layer wind field at 1900 PDT with the radar-derived winds (for 1850 PDT) shows some disagreement (Figures C-13g and h). A strong cyclonic circulation in the analyzed field does not show up in the radar-derived wind field. Strong southwesterly winds observed at Buoy F and weaker southwesterly winds at Platform C disagree with the pattern indicated by the dual-Doppler data. Northwesterly flow in the northwestern corner of the dual-Doppler-radar grid is in agreement with the dual-Doppler data.

A similar situation exists at 2000 PDT (Figures C-13i and j). Southwesterly flow at Buoy F does not agree with the northwesterly flow observed at this location by the dual-Doppler radar (at 1950 PDT). The analyzed wind field also shows an area of very light winds in the the central Channel. This feature is not present in the dual-Doppler data. Finally, northwesterly flow in the northwestern corner of the dual-Doppler-radar grid and some light northerly winds along the northern edge of the grid show agreement with the radar-derived winds.

At 2100 PDT, the analyzed wind field exhibits strong northwesterly winds in the western two-thirds of the dual-Doppler-radar domain (Figure C-13k). This is in agreement with the radar-derived winds in this region at 2050 PDT (Figure C-13l). However, westerly flow, which is apparent in the radar-derived winds along the southern boundary of the dual-Doppler-radar grid, is not present in the analyzed wind field. An area of very light winds, which also does not agree with the radar-derived winds in this area, is analyzed in the southeastern corner of the grid. Both wind fields indicate the penetration of offshore flow into the Channel.

The analyzed winds over the Channel are derived from the objective analysis of the available observations in the region. When the observations are in agreement with the dual-Doppler data, the objective analysis provides a reasonable depiction of the airflow in the western and central Channel. However, when observations in and around the channel disagree with the Doppler measurements, the objective analysis procedure is not able to provide a wind field that is consistent with the dual-Doppler-radar derived wind field. At 1900 and 2000 PDT, observations at Buoy F, which is located within the Channel, are in direct disagreement with the dual-Doppler data, causing the analysis to disagree as well. If Buoy F is removed from the input to the diagnostic wind model and the wind fields are regenerated, some discrepancies still appear in the Channel. Figure C-14 shows the diagnostic-wind-model analyzed wind fields for 1900 and 2000 PDT regenerated without the Buoy F observation. Use of the surrounding observations in the objective analysis does not provide a sufficiently accurate depiction of the wind field in the Channel. This indicates that in order to accurately depict the airflow in the western and central Santa Barbara Channel it is important to obtain accurate information about the airflow from observations in the region.

Finally, the dual-Doppler-radar derived winds appear to provide significant information about the airflow patterns in the Santa Barbara Channel. An additional comparison for 0700 PDT on 20 September is presented in Figure C-15. A mid-channel eddy is clearly depicted in the dual-Doppler-radar derived wind field (Figure C-15b). This feature may play an important role in the transport of pollutants in the Santa Barbara Channel area. The eddy, however, is not clearly present in the analyzed wind field for this time (Figure C-15a).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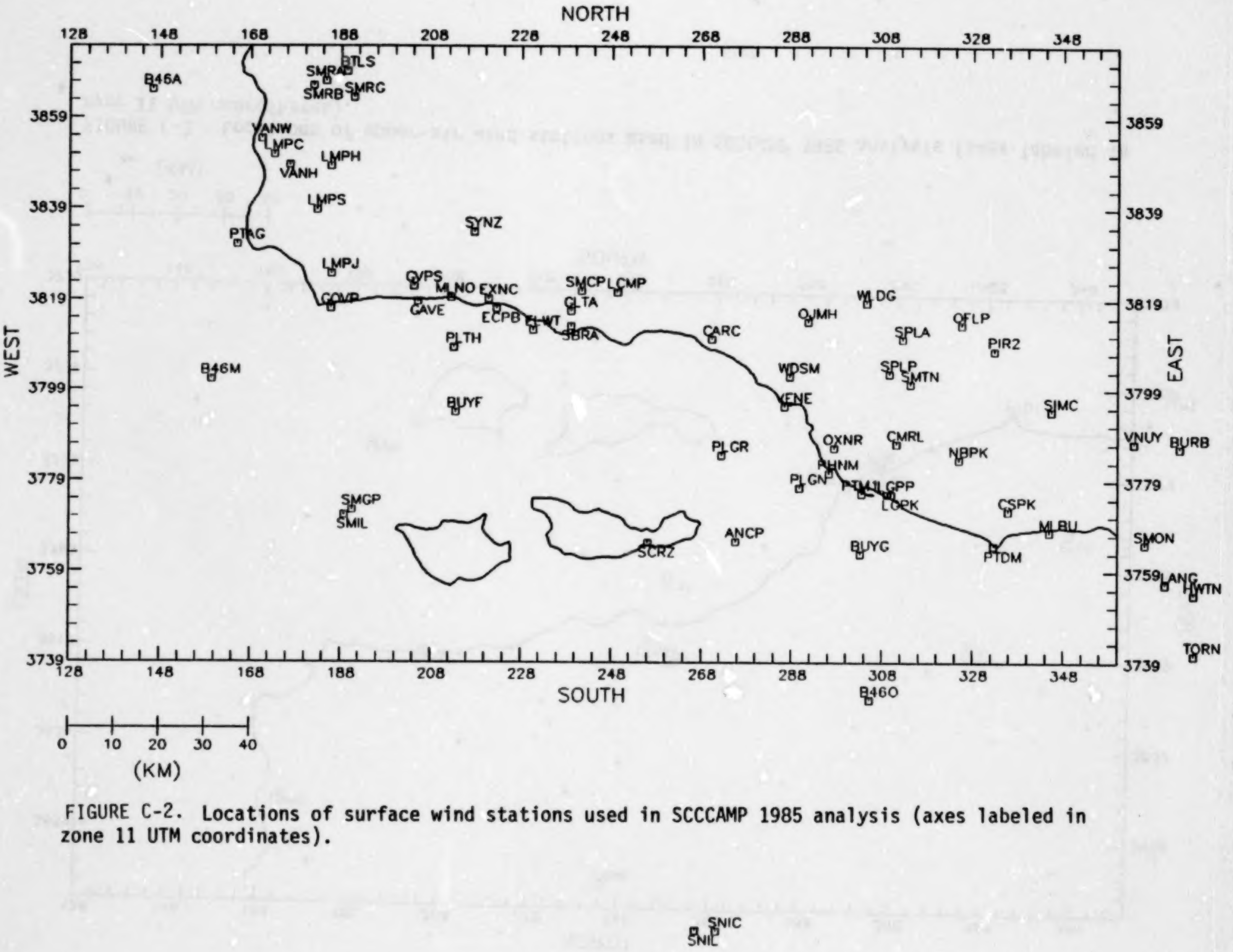
(KM)

FIGURE C-1. The SCCCAMP 1985 analysis domain (axes labeled in zone 11 UTM coordinates; topography contoured in meters).

87182r1

87182r1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SMRA
SMRB
SMRG
VANW
LMPC
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LMPH
LMPS
PTAG
SYNZ
LMPJ
OVPS
COVP
GAVE
MLNO
EXNC
ECPB
ELWT
SMCP
LCMP
CLTA
SBRA
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B46M
BUYF
CARC
OJMH
WLDG
SPLA
OFLP
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WDSM
SPLP
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VENE
SJMC
OXNR
CMRL
VNUY
BURB
PLGR
NBPK
RHNM
PLGN
PTMU
LGPP
LOPK
CSPK
SMGP
SMIL
ANCP
SCRZ
BUYG
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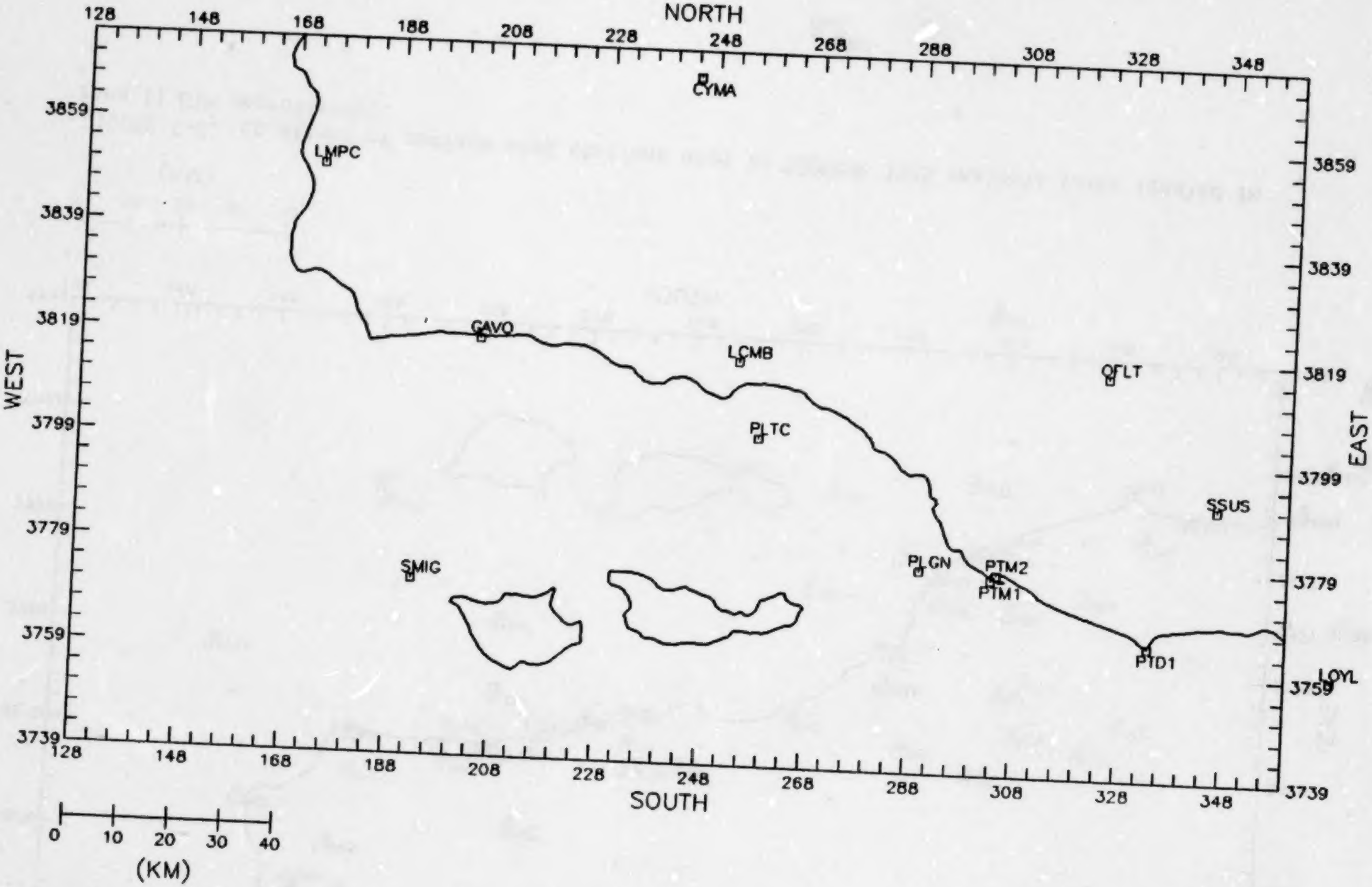
(KM)

FIGURE C-2. Locations of surface wind stations used in SCCCAMP 1985 analysis (axes labeled in zone 11 UTM coordinates).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GAVO
LCMB
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SMIG
PLGN
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PTM1
PTD1
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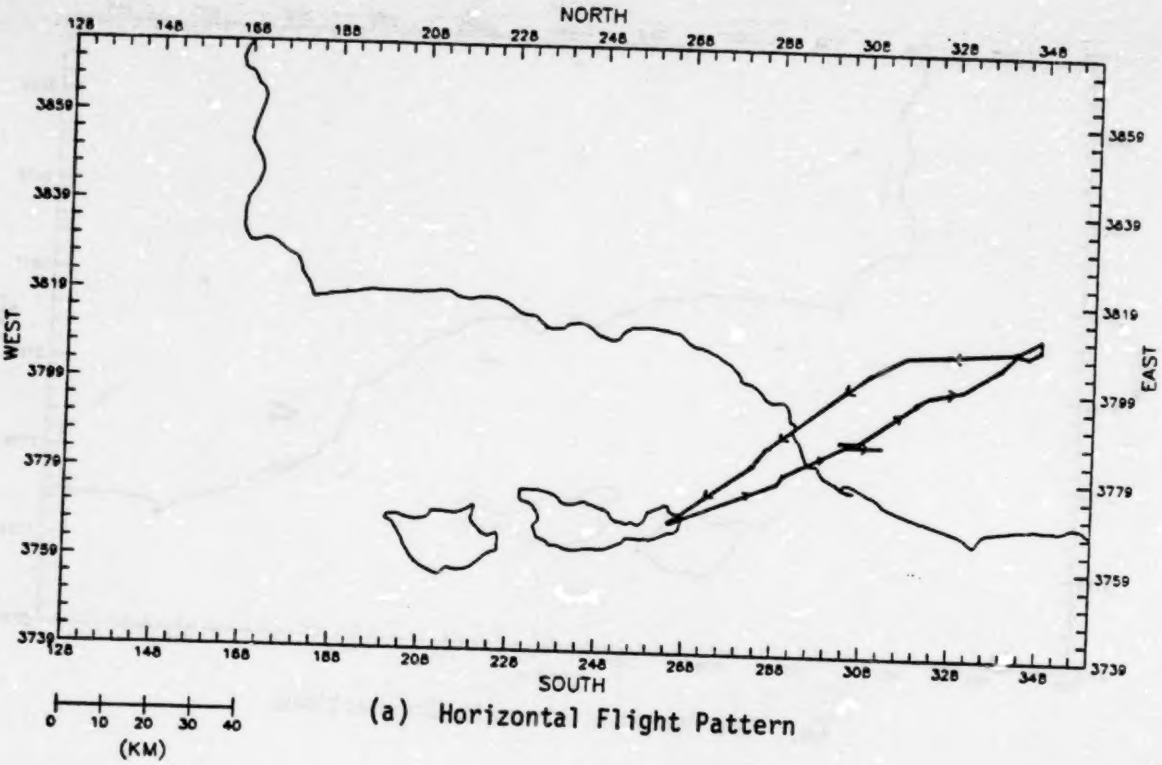
FIGURE C-3. Locations of upper-air wind stations used in SCCCAMP 1985 analysis (axes labeled in zone 11 UTM coordinates).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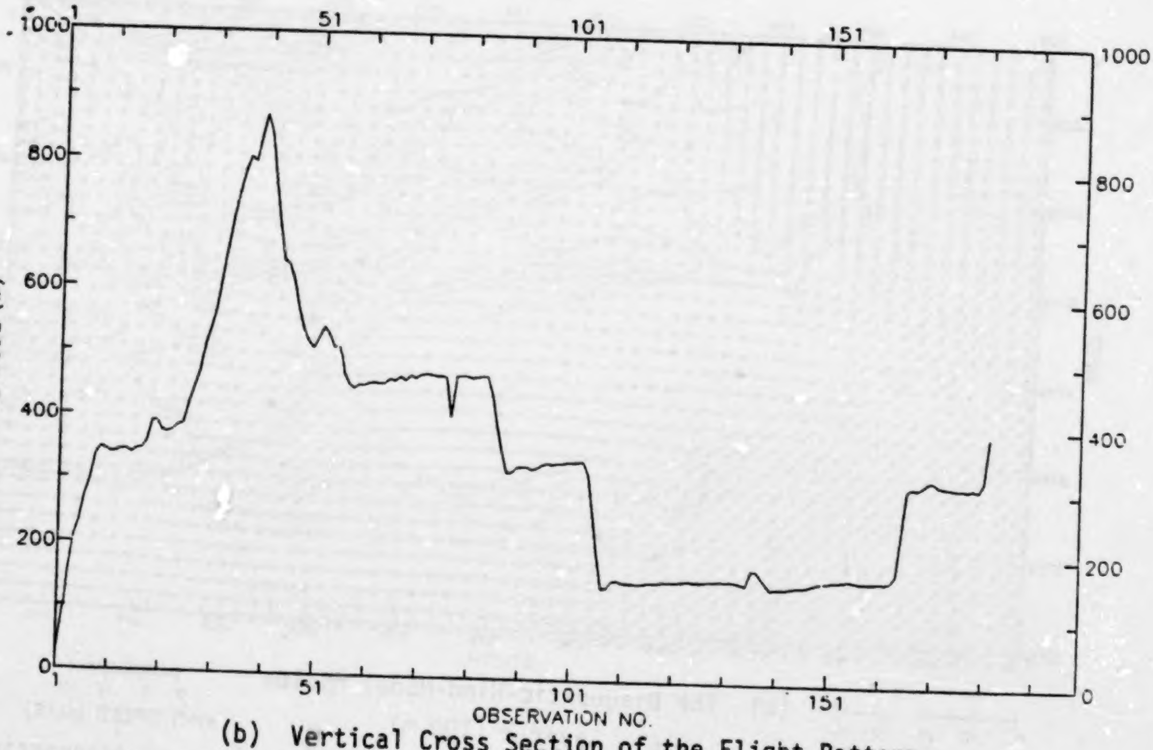
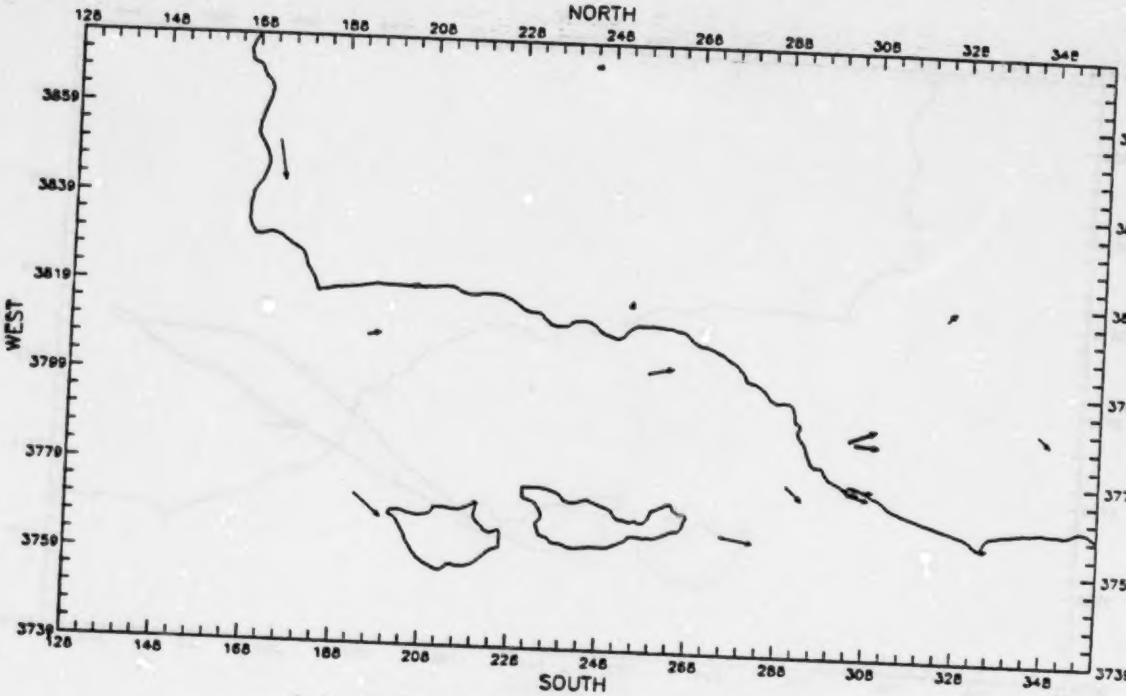
(KM)

(a) Horizontal Flight Pattern



(b) Vertical Cross Section of the Flight Pattern

FIGURE C-4. Flight No. 1 horizontal and vertical flight patterns.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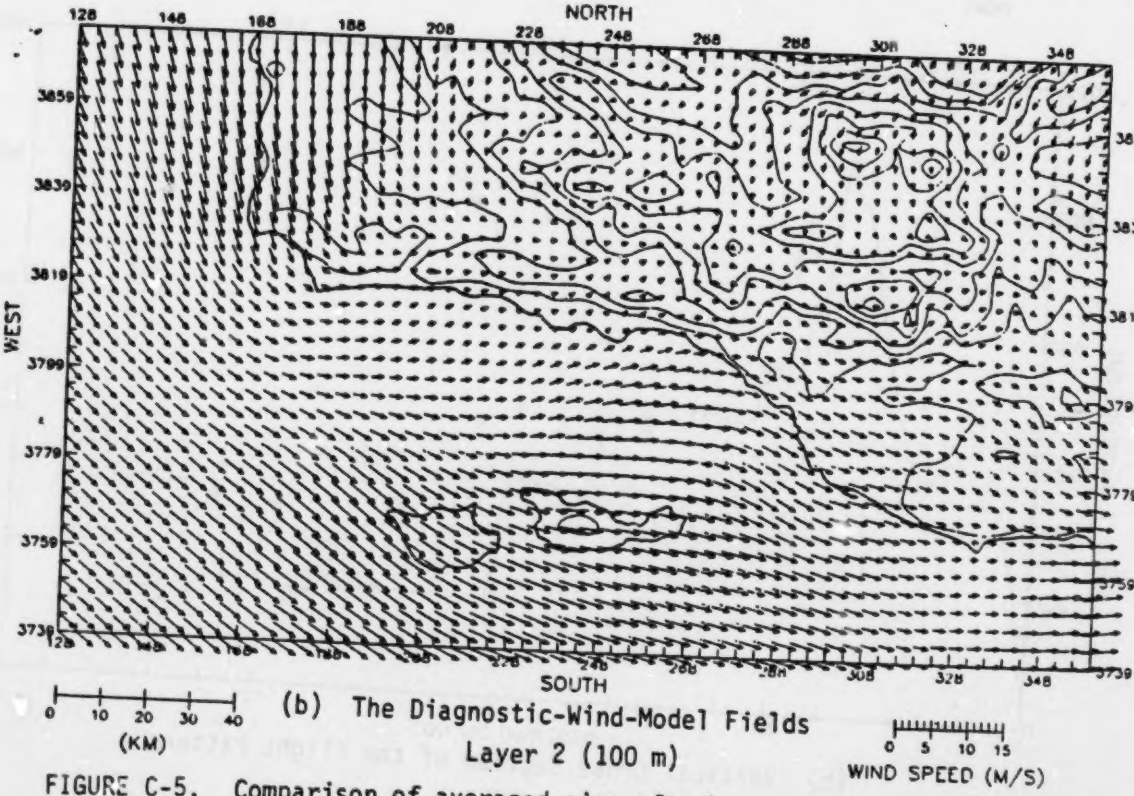
(a) The Averaged Aircraft Observations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(KM)
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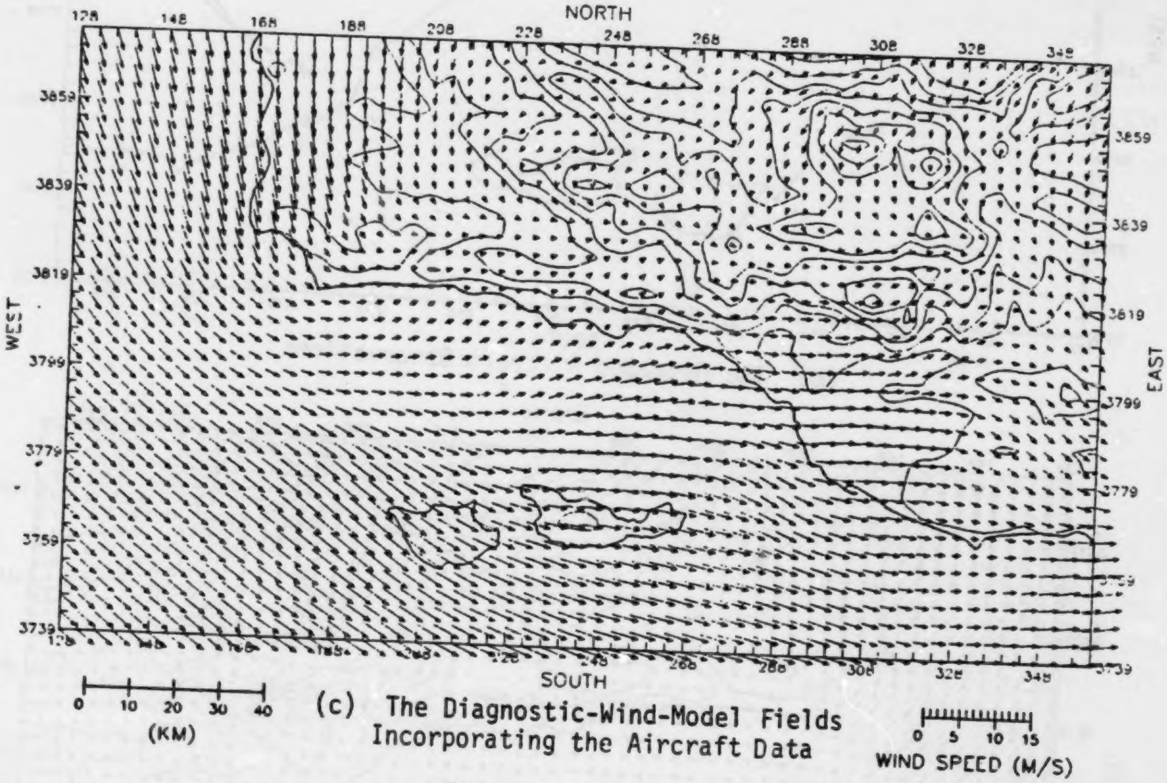
15
WIND SPEED (M/S)

(b) The Diagnostic-Wind-Model Fields
Layer 2 (100 m)

FIGURE C-5. Comparison of averaged aircraft observations and diagnostic-wind-fields with and without aircraft data for 1200 PDT. The aircraft observations are plotted in boldface.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(KM)
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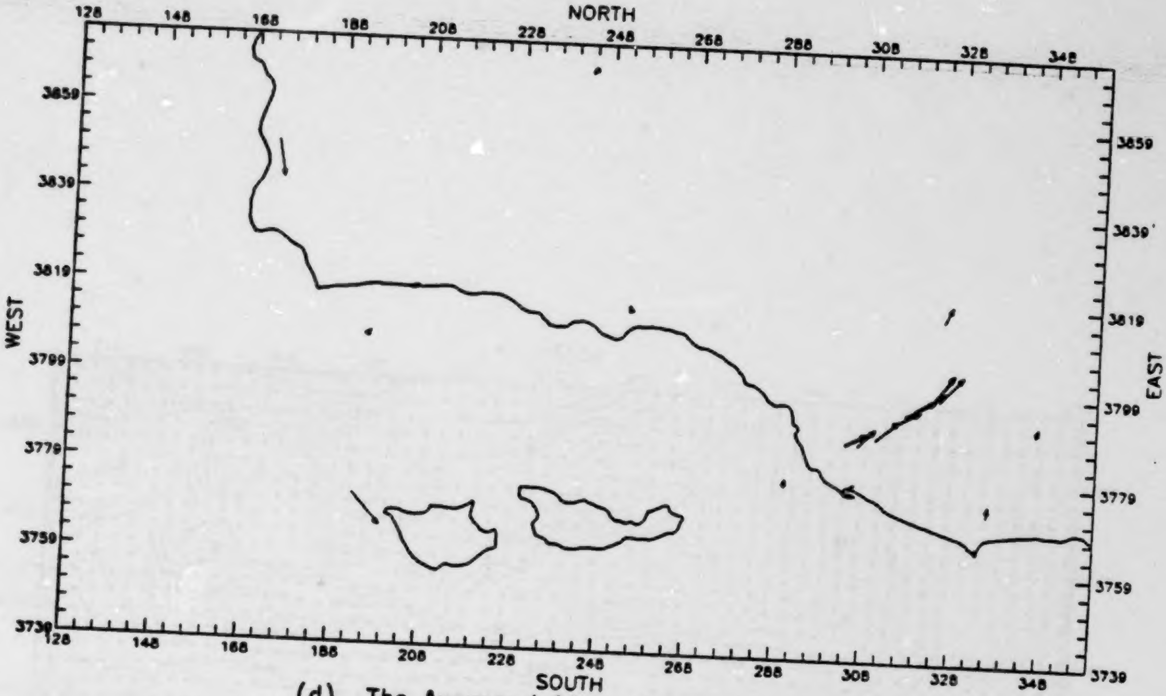
WIND SPEED (M/S)

(c) The Diagnostic-Wind-Model Fields Incorporating the Aircraft Data

Layer 2 (100 m)

FIGURE C-5. Continued.


NORTH
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WEST
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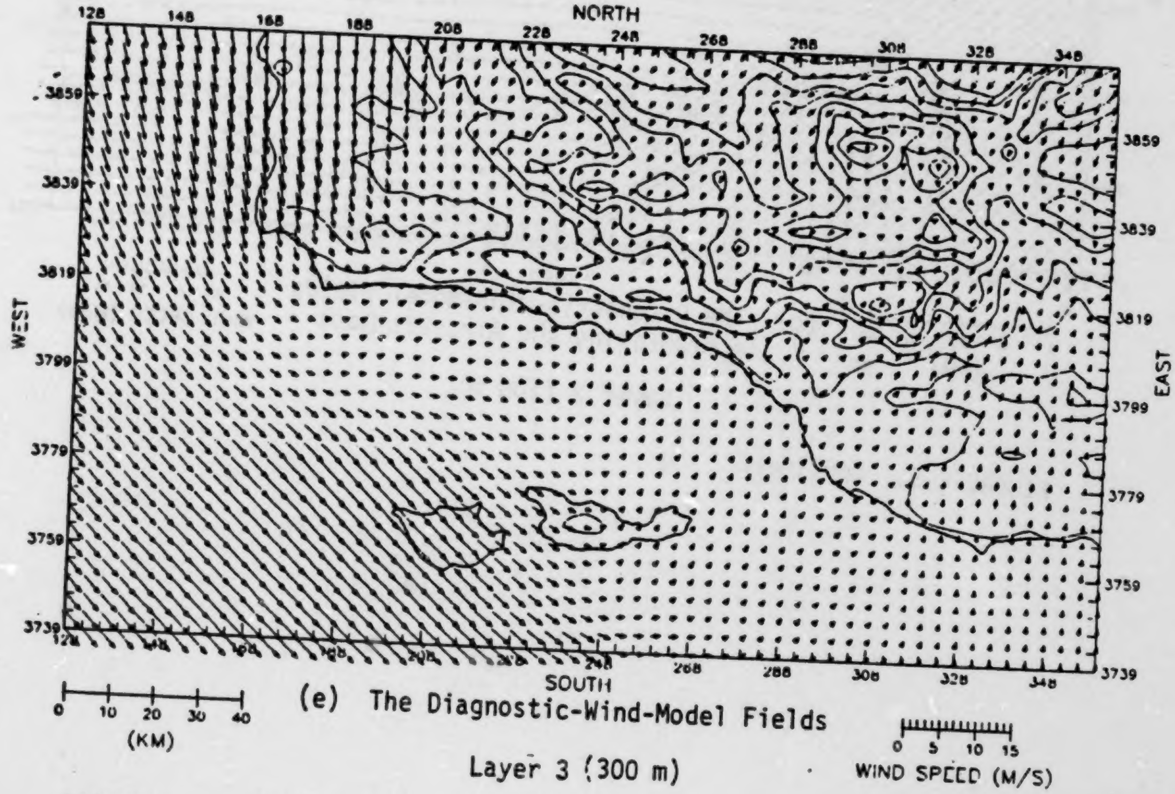
SOUTH

(d) The Averaged Aircraft Observations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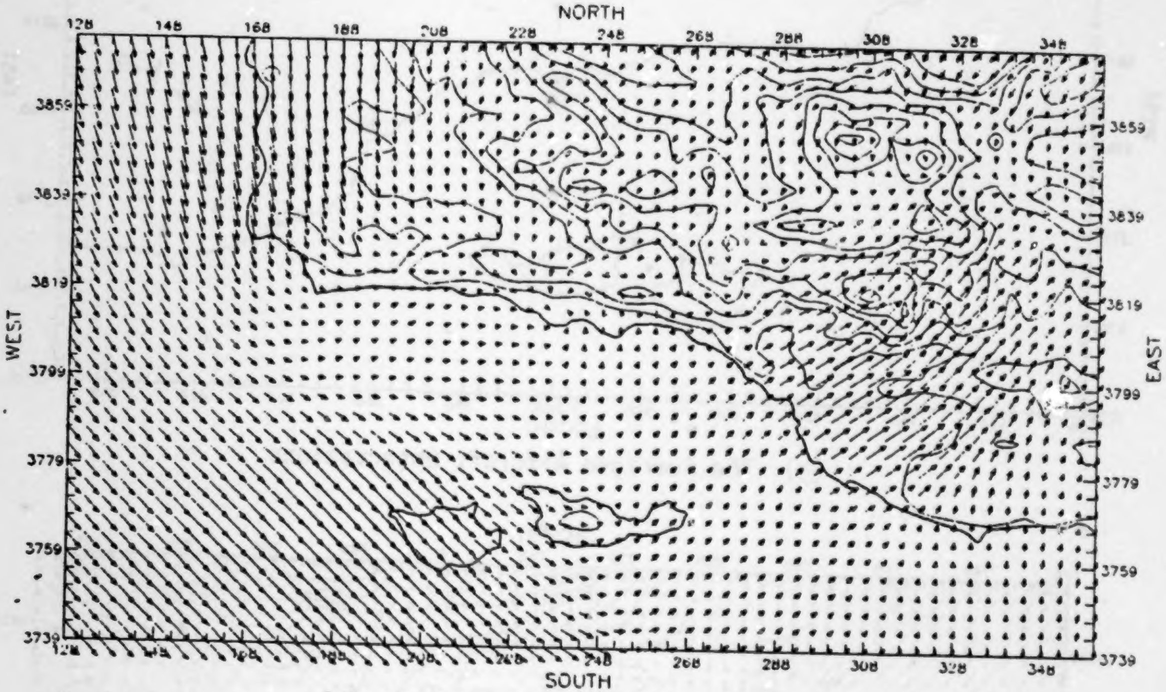
(KM)
0 5 10 15
WIND SPEED (M/S)

(e) The Diagnostic-Wind-Model Fields

Layer 3 (300 m)

FIGURE C-5. Continued.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(KM)
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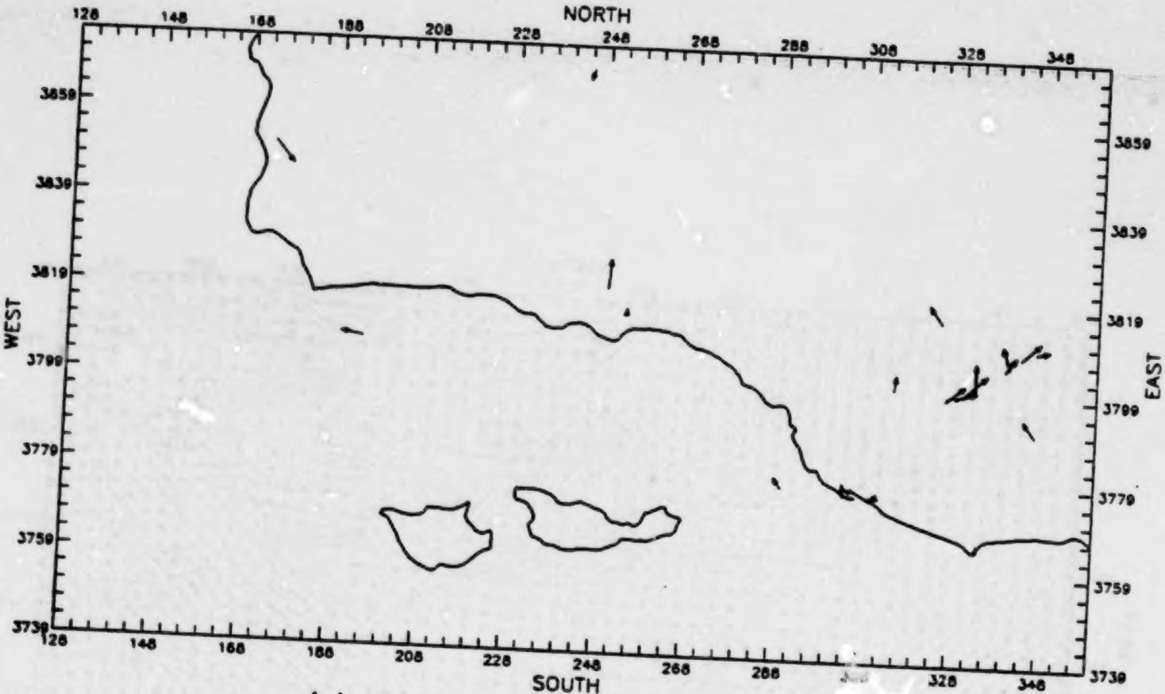
WIND SPEED (M/S)

(f) The Diagnostic-Wind-Model Fields Incorporating the Aircraft Data

Layer 3 (300 m)

FIGURE C-5. Continued.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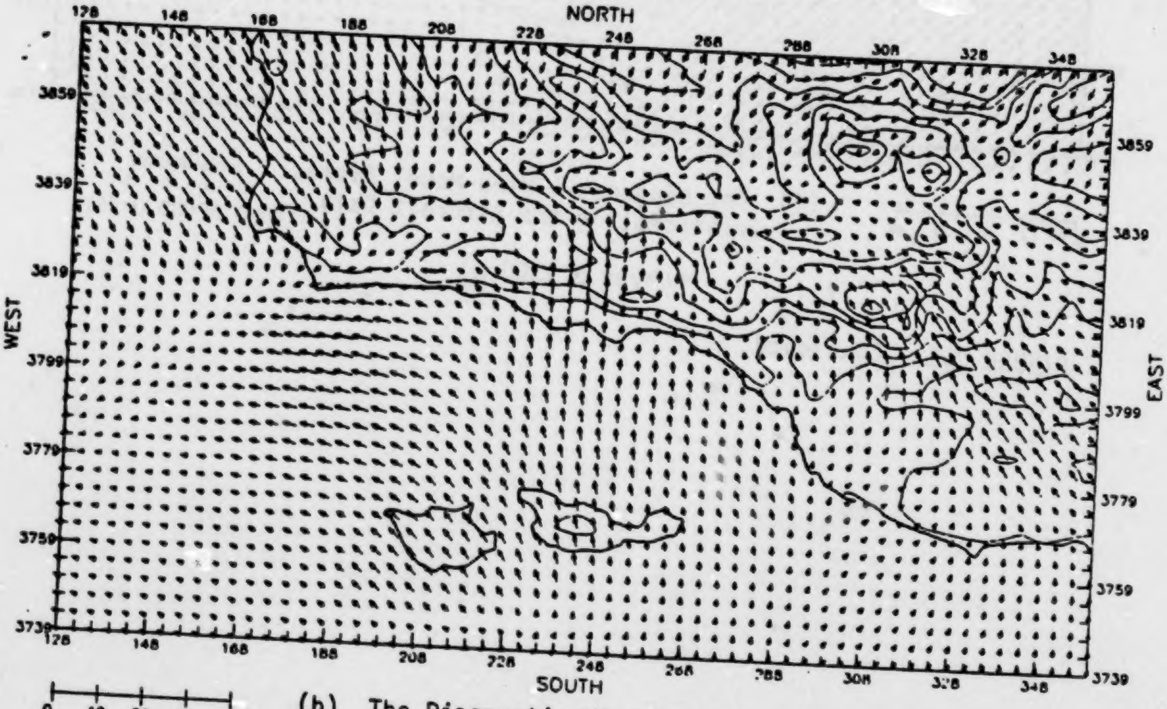
(g) The Averaged Aircraft Observations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(KM)
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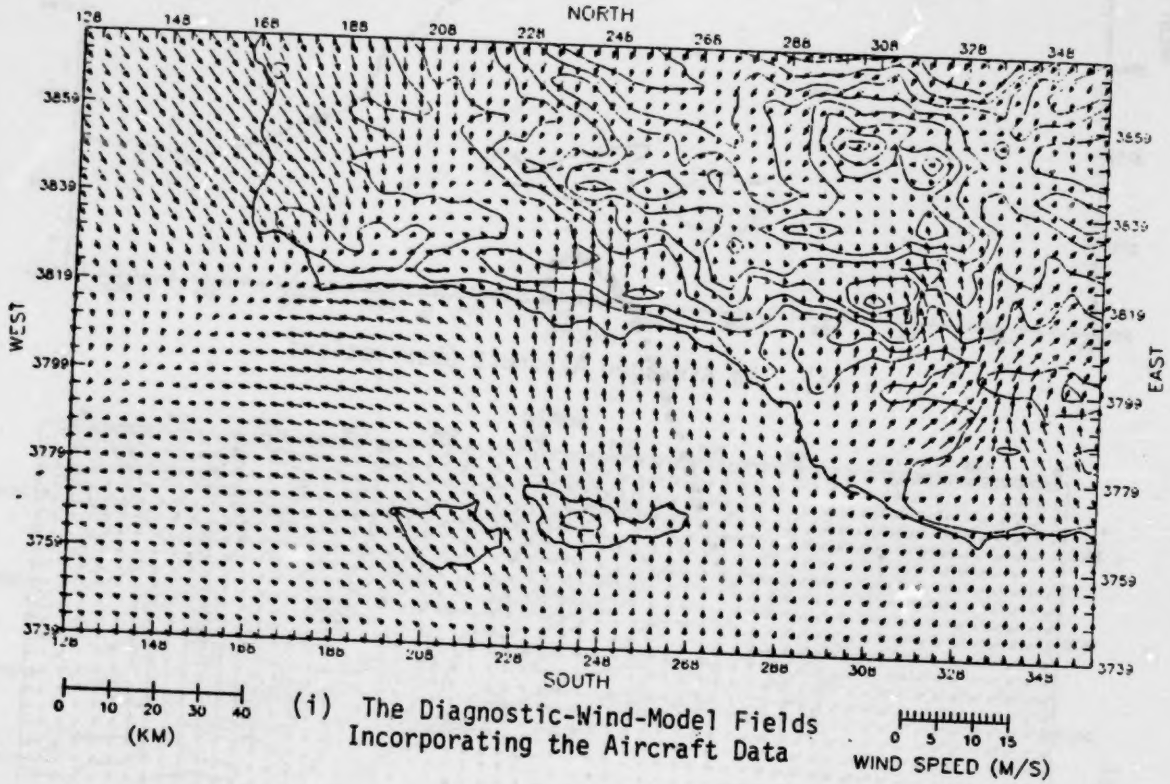
WIND SPEED (M/S)

(h) The Diagnostic-Wind-Model Fields

Layer 4 (600 m)

FIGURE C-5. Continued.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(KM)
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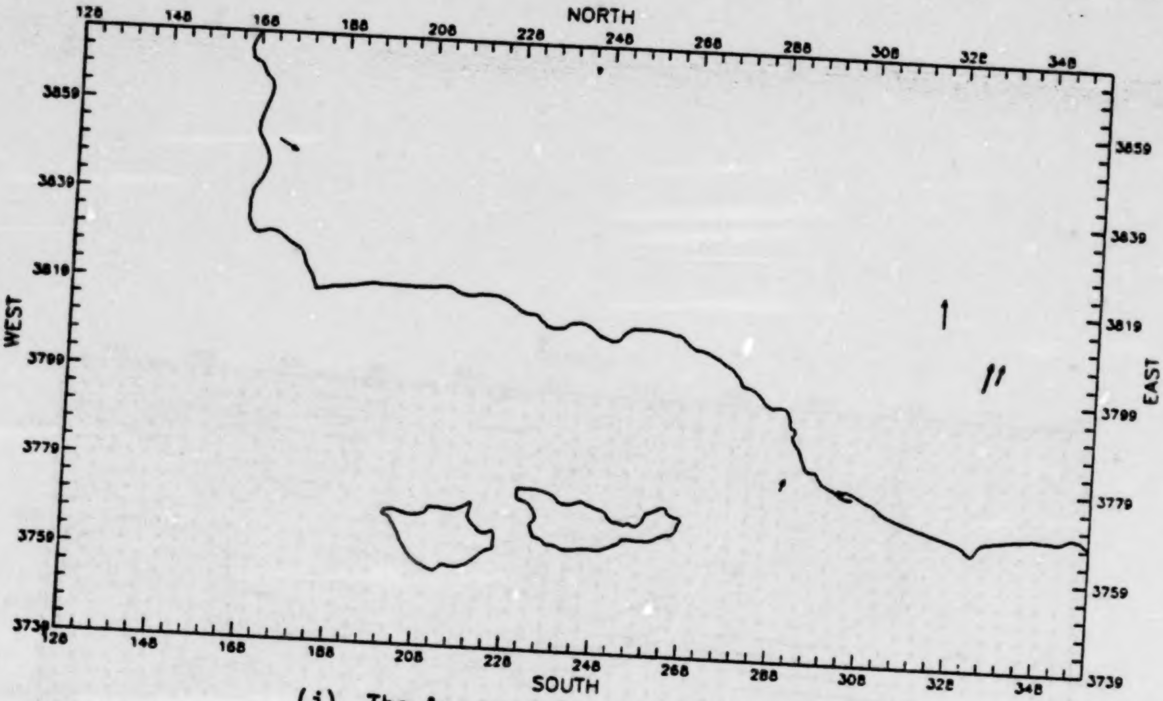
WIND SPEED (M/S)

(i) The Diagnostic-Wind-Model Fields Incorporating the Aircraft Data

Layer 4 (600 m)

FIGURE C-5. Continued.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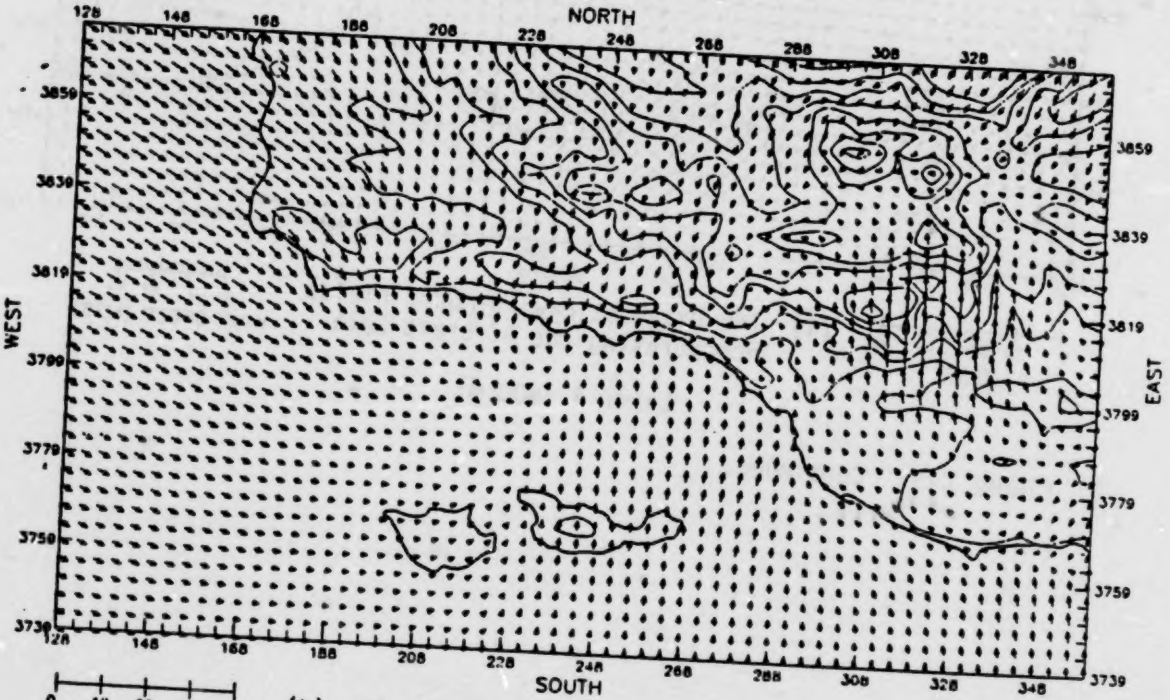
(j) The Averaged Aircraft Observations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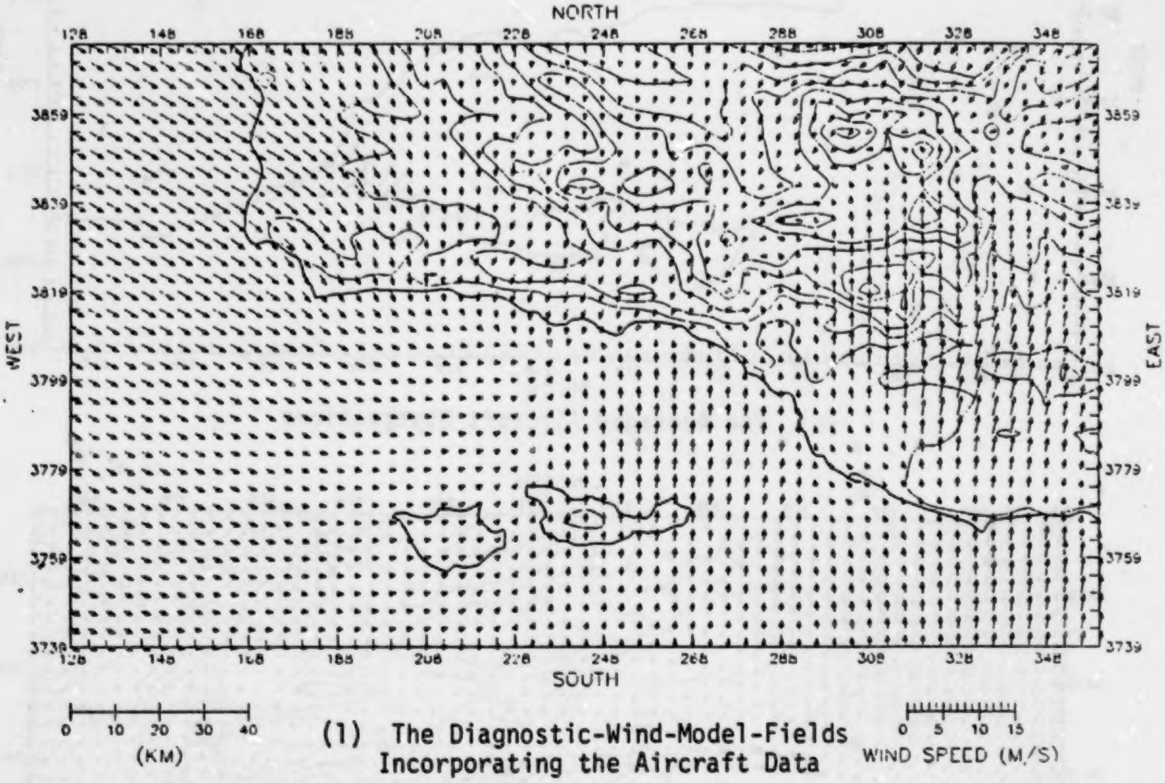
WIND SPEED (M/S)

(k) The Diagnostic-Wind-Model Fields

Layer 5 (1000 m)

FIGURE C-5. Continued.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(KM)
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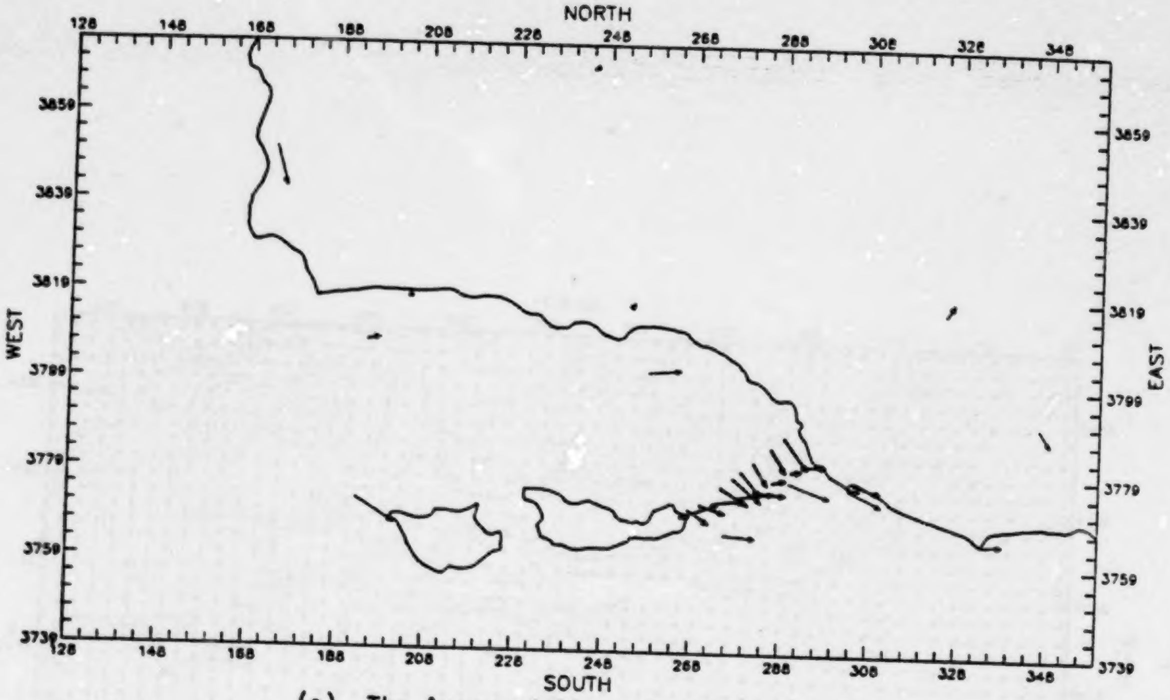
WIND SPEED (M/S)

(1) The Diagnostic-Wind-Model-Fields Incorporating the Aircraft Data

Layer 5 (1000 m)

FIGURE C-5. Concluded.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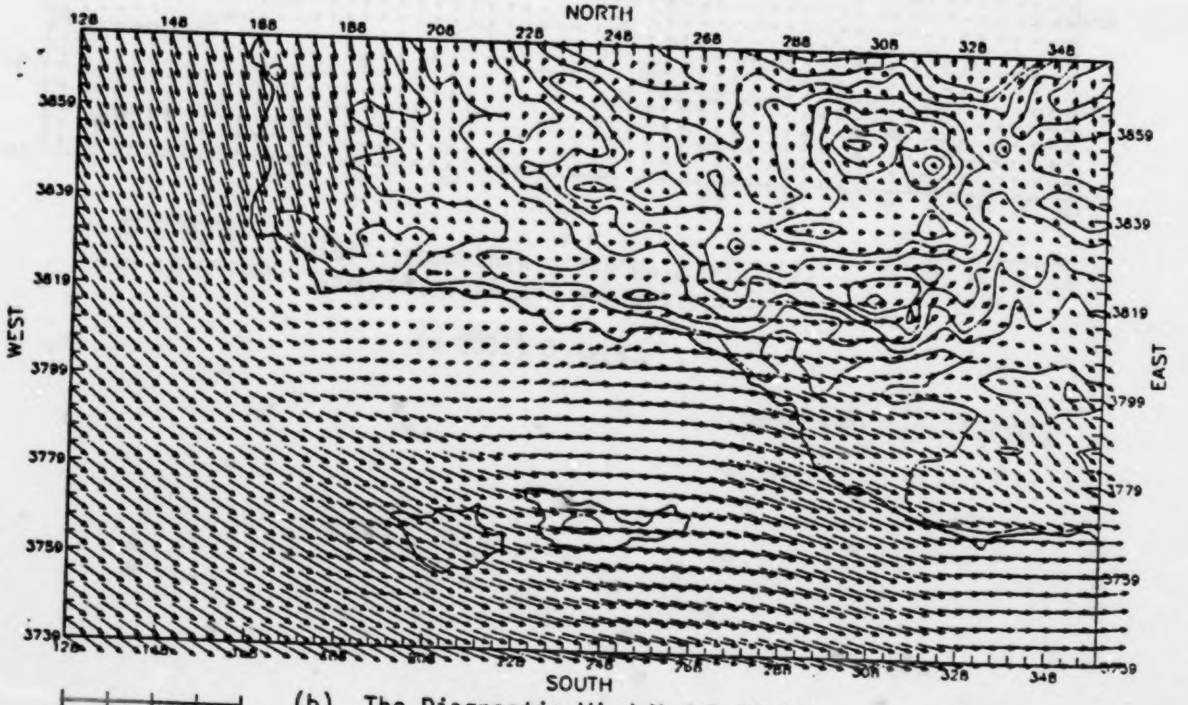
(a) The Averaged Aircraft Observations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(KM)
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WIND SPEED (M/S)

(b) The Diagnostic-Wind-Model Fields

Layer 2 (100 m)

FIGURE C-6. Comparison of averaged aircraft observations and diagnostic-wind-model fields with and without aircraft data for 1300 PDT. The aircraft observations are plotted in boldface.

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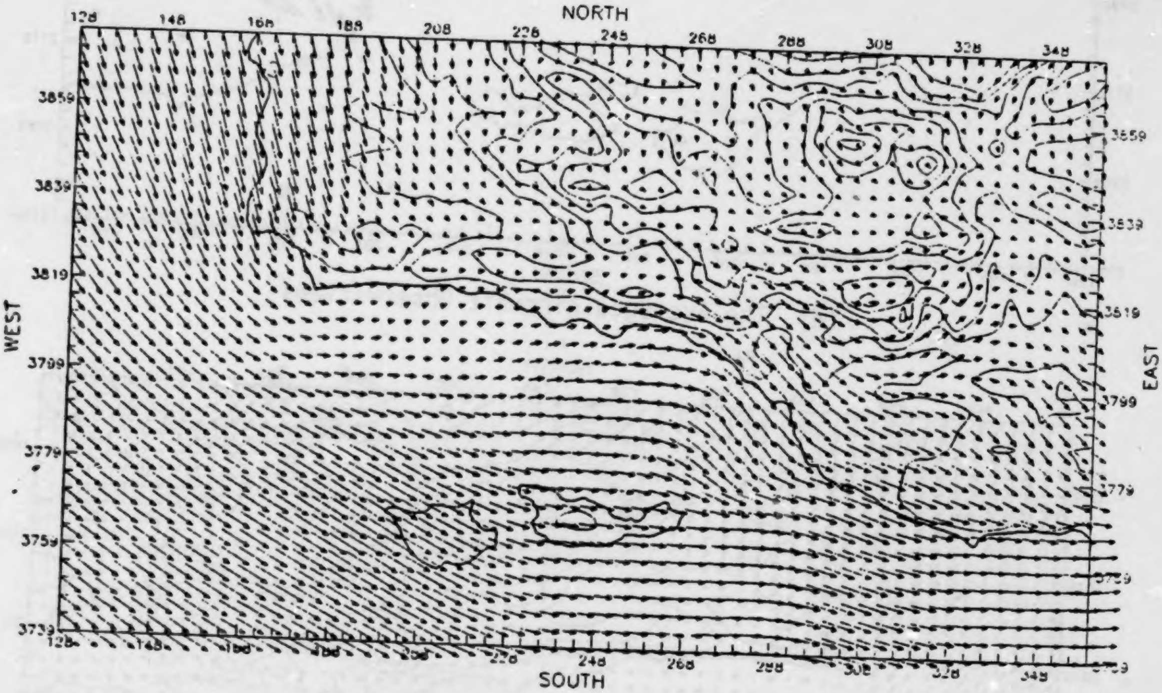
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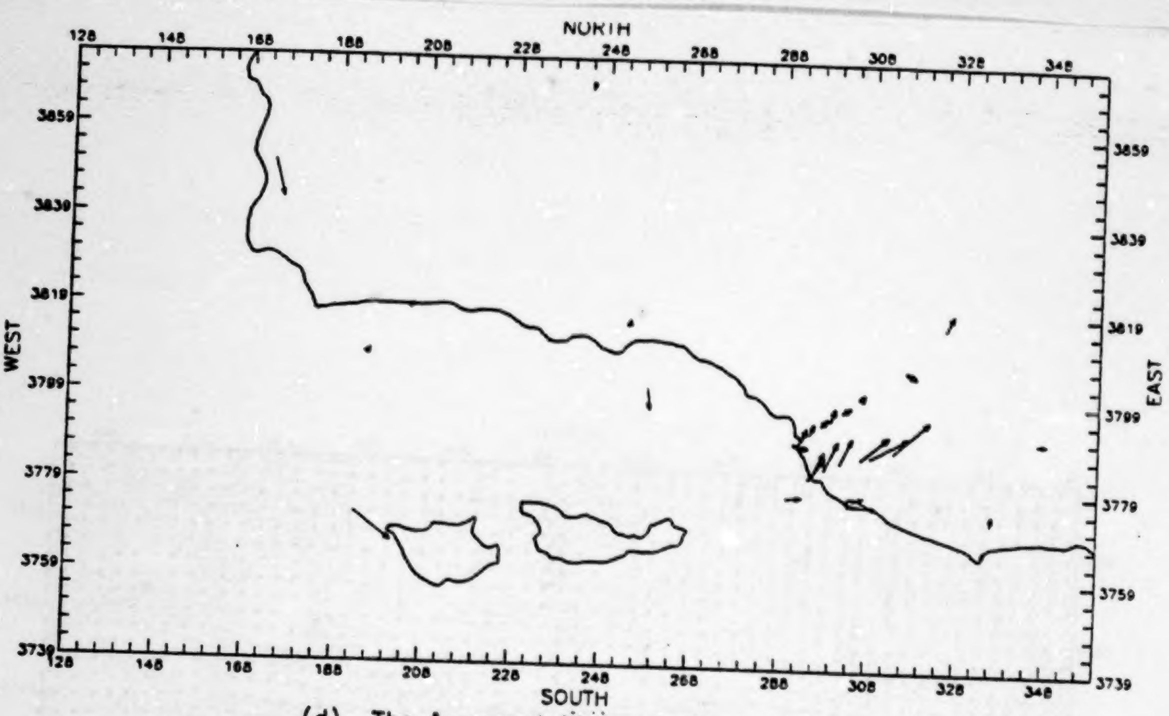
(c) The Diagnostic-Wind-Model Fields Incorporating the Aircraft Data

Layer 2 (100 m)

FIGURE C-6. Continued.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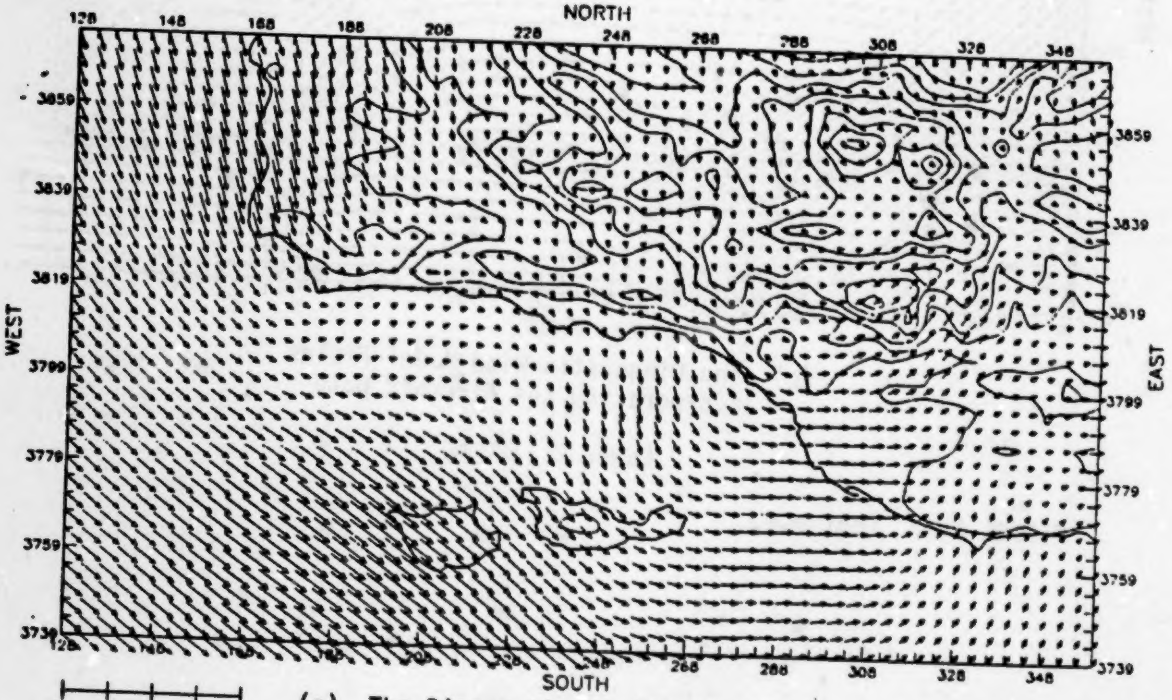
(d) The Averaged Aircraft Observations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10
20
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(KM)
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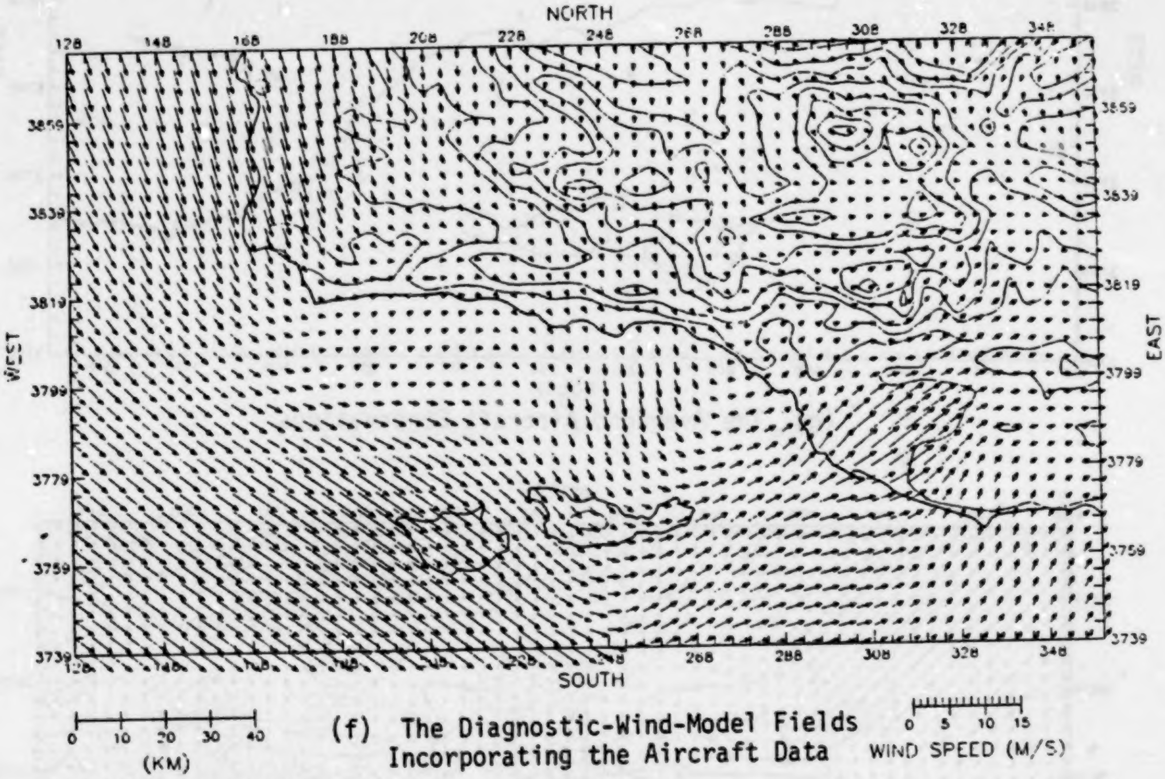
15
WIND SPEED (M/S)

(e) The Diagnostic-Wind-Model Fields
Layer 3 (300 m)

FIGURE C-6. Continued.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3739
0 10 20 30 40
(KM)
0 5 10 15
WIND SPEED (M/S)

(f) The Diagnostic-Wind-Model Fields Incorporating the Aircraft Data

Layer 3 (300 m)

FIGURE C-6. Continued.

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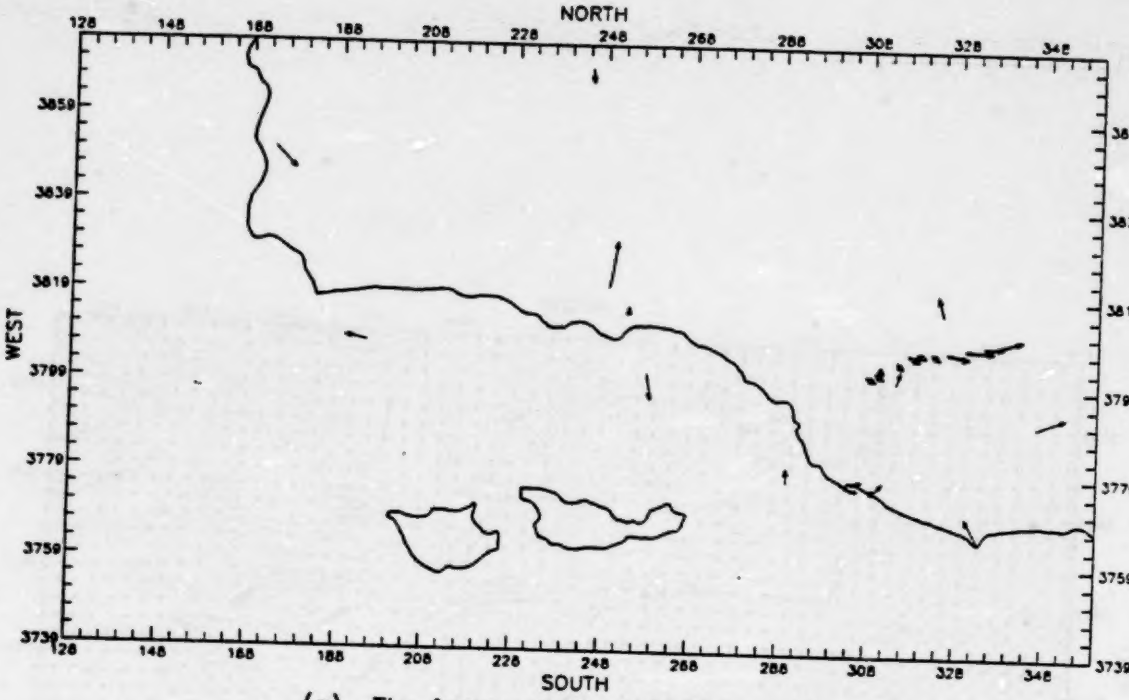
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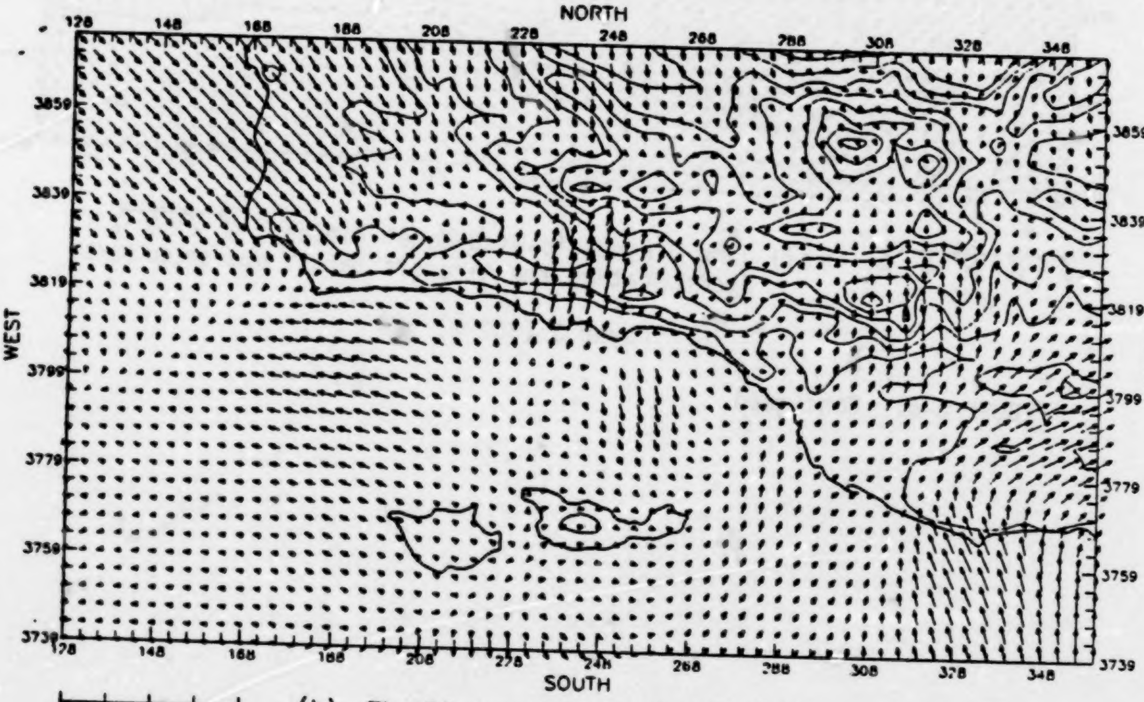
(g) The Averaged Aircraft Observations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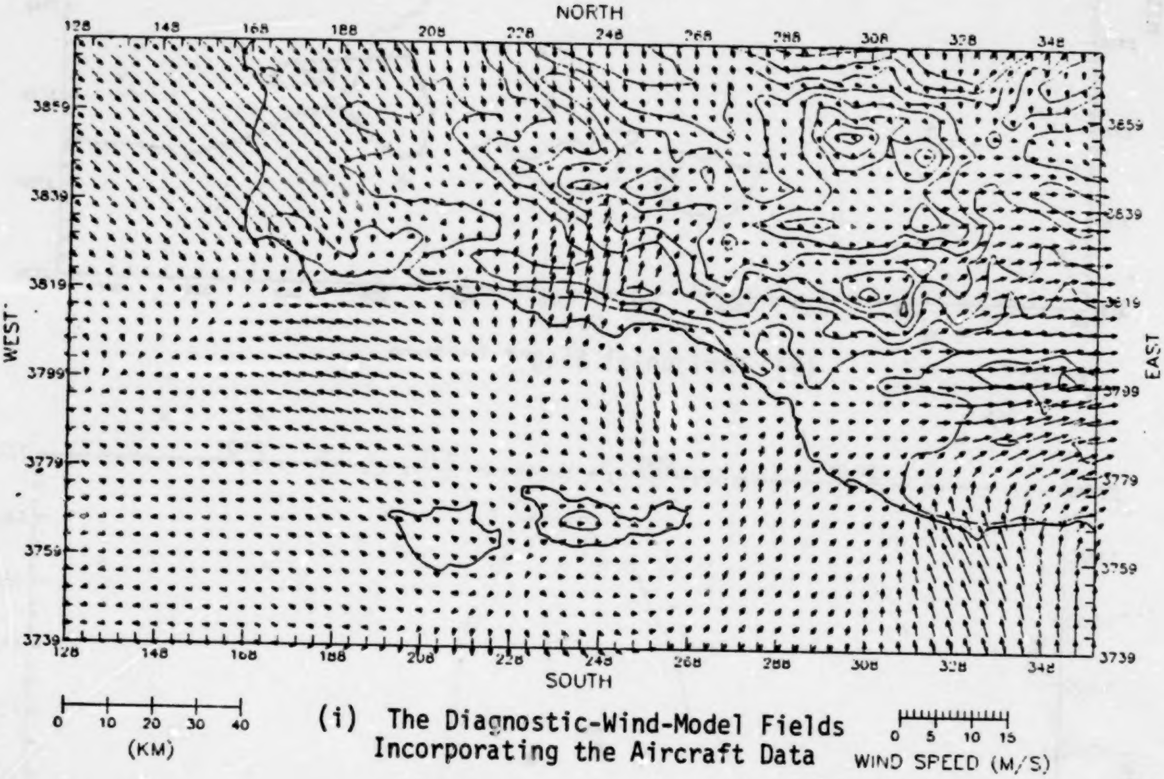
0 10 20 30 40
(KM)
0 5 10 15
WIND SPEED (M/S)

(h) The Diagnostic-Wind-Model Fields

Layer 4 (600 m)

FIGURE C-6. Continued.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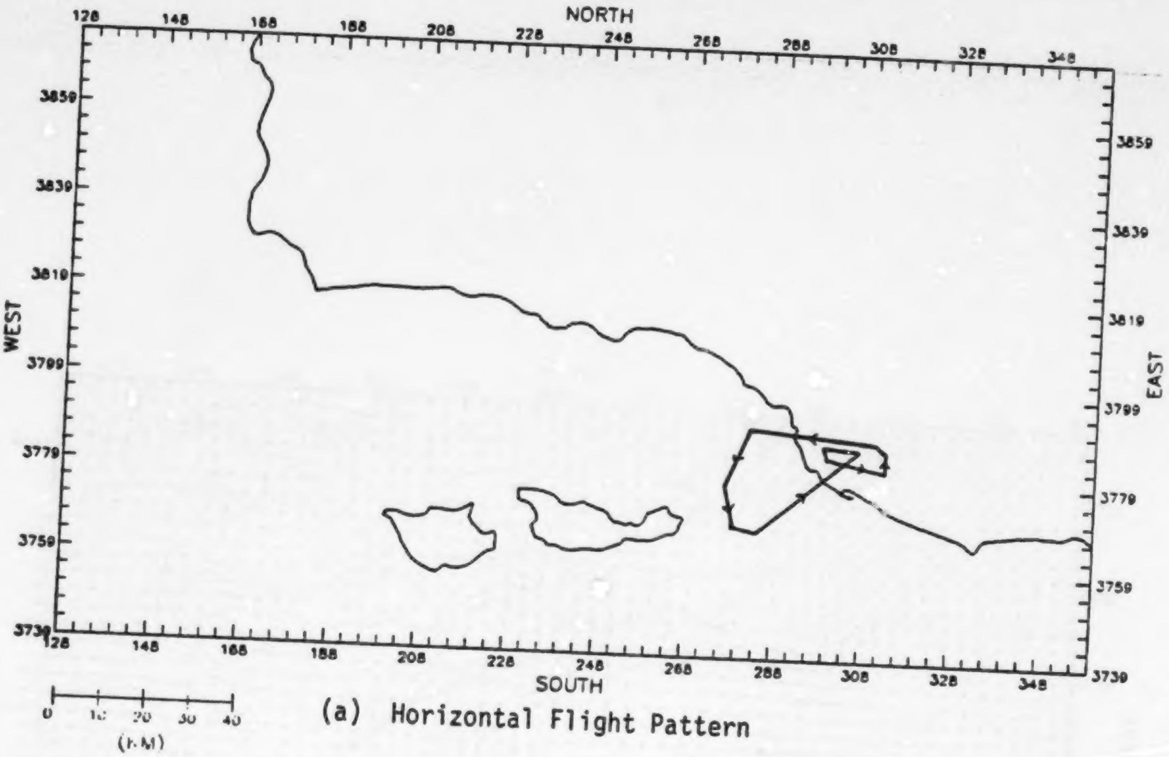
0 10 20 30 40
(KM)
0 5 10 15
WIND SPEED (M/S)

(i) The Diagnostic-Wind-Model Fields Incorporating the Aircraft Data

Layer 4 (600 m)

FIGURE C-6. Concluded.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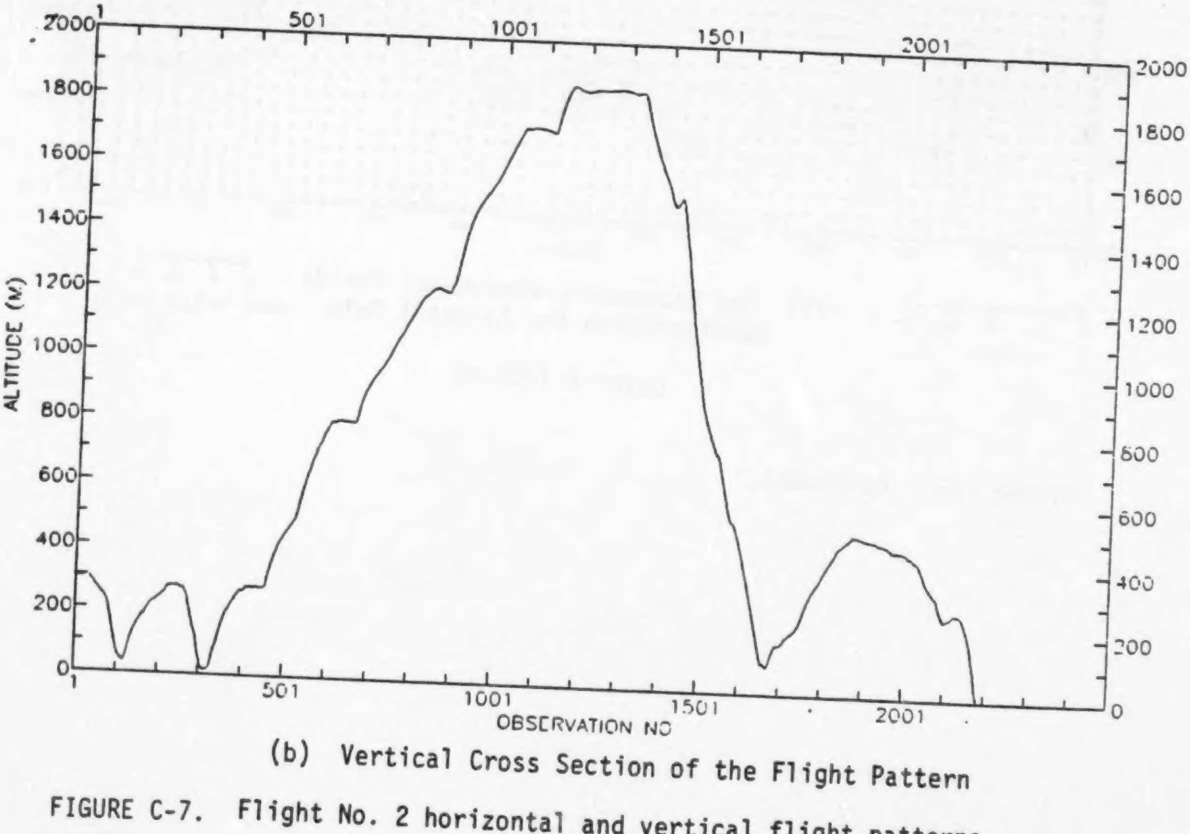
(KM)

(a) Horizontal Flight Pattern



(b) Vertical Cross Section of the Flight Pattern

FIGURE C-7. Flight No. 2 horizontal and vertical flight patterns.

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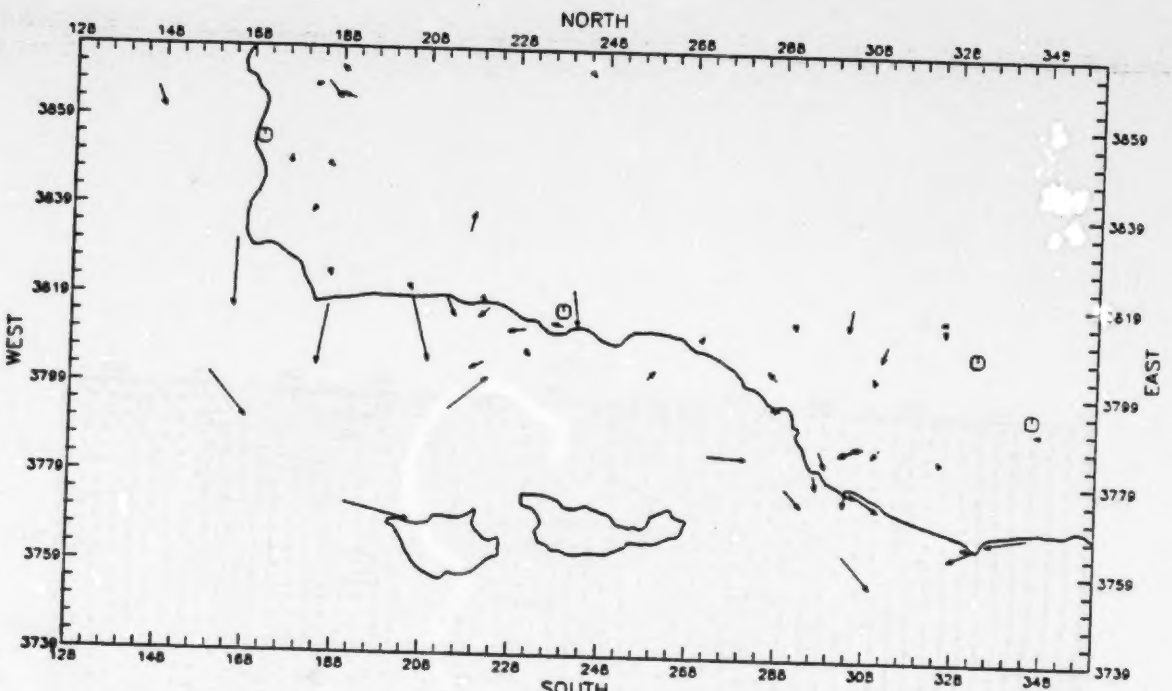
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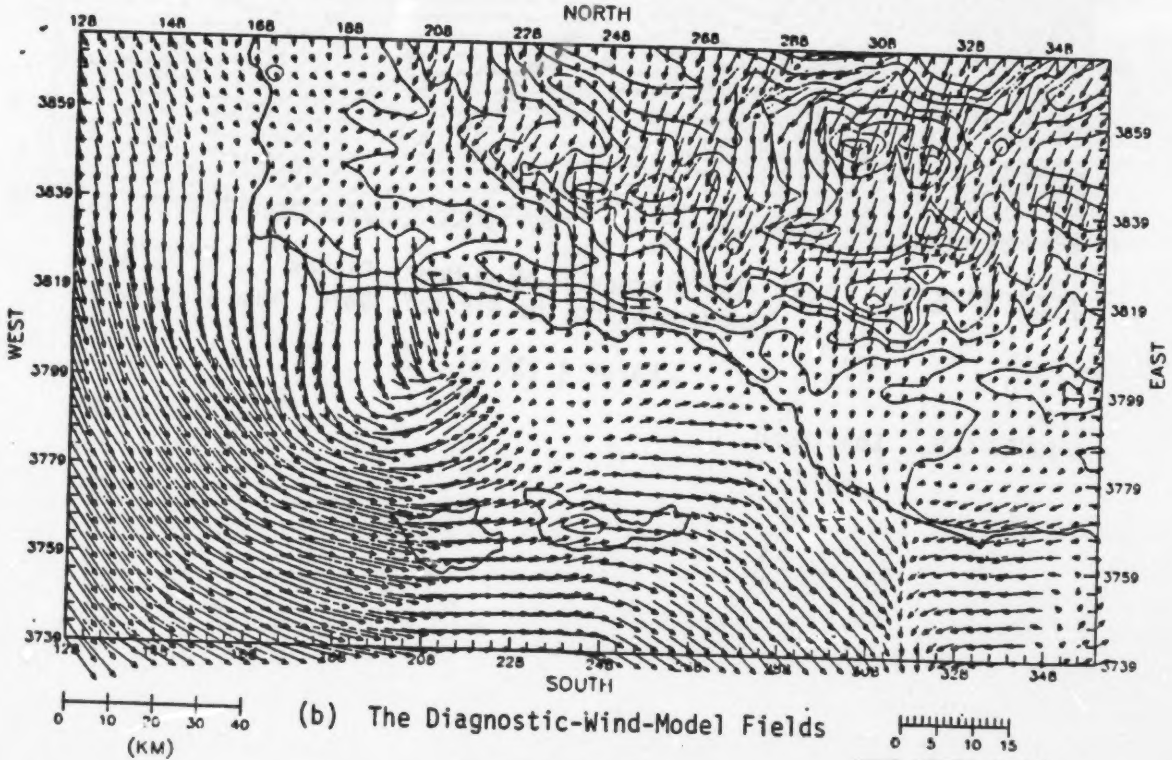
(a) The Averaged Aircraft Observations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40
(KM)
0
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WIND SPEED (M/S)

(b) The Diagnostic-Wind-Model Fields

Layer 1 (10 m)

FIGURE C-8. Comparison of averaged aircraft observations and diagnostic-wind-model fields with and without aircraft data for 2000 PDT. The aircraft observations are plotted in boldface.

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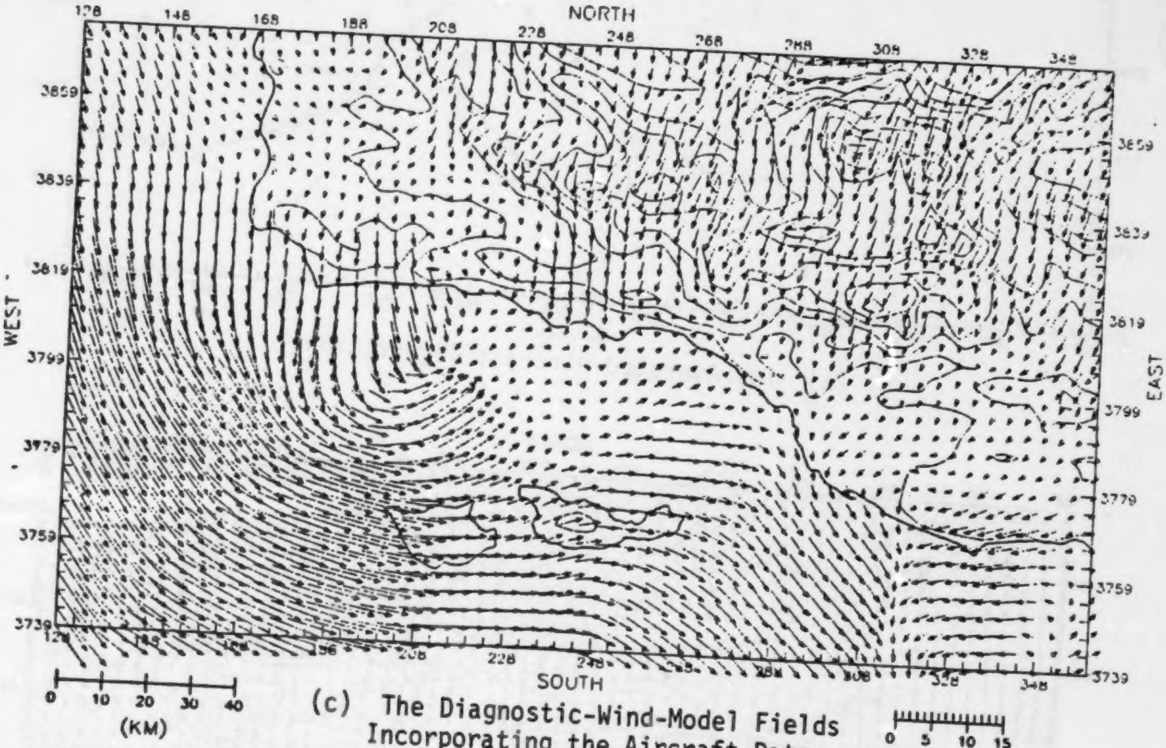
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(KM)
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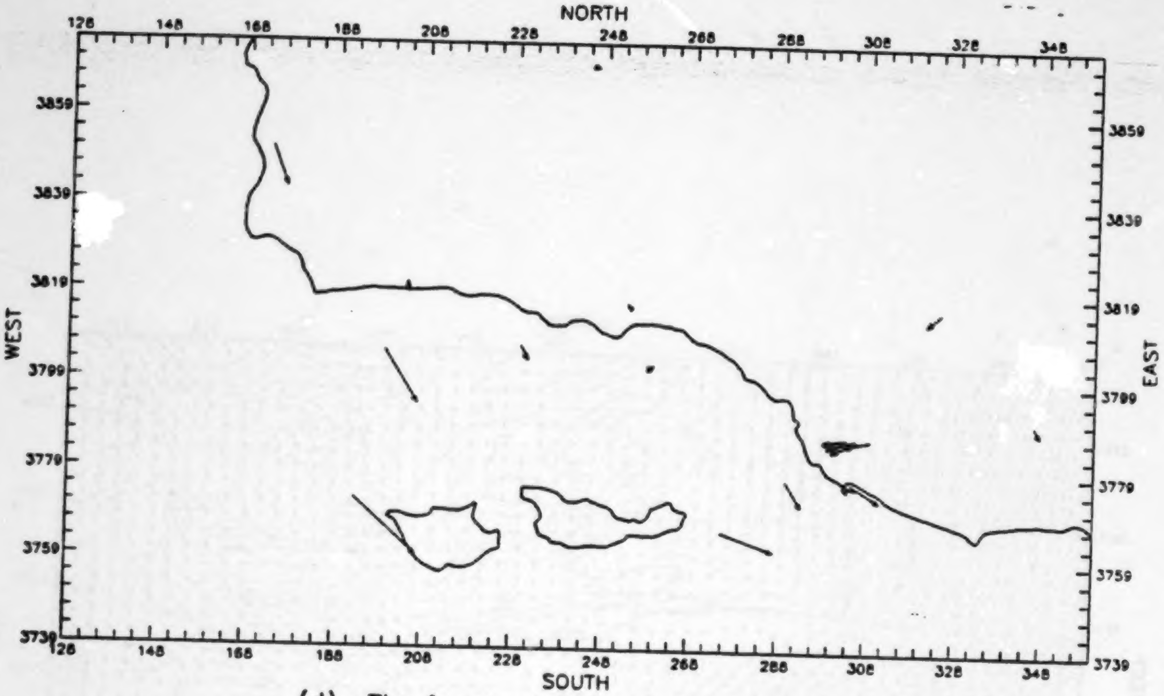
15
WIND SPEED (M/S)

(c) The Diagnostic-Wind-Model Fields Incorporating the Aircraft Data

Layer 1 (10 m)

FIGURE C-8. Continued.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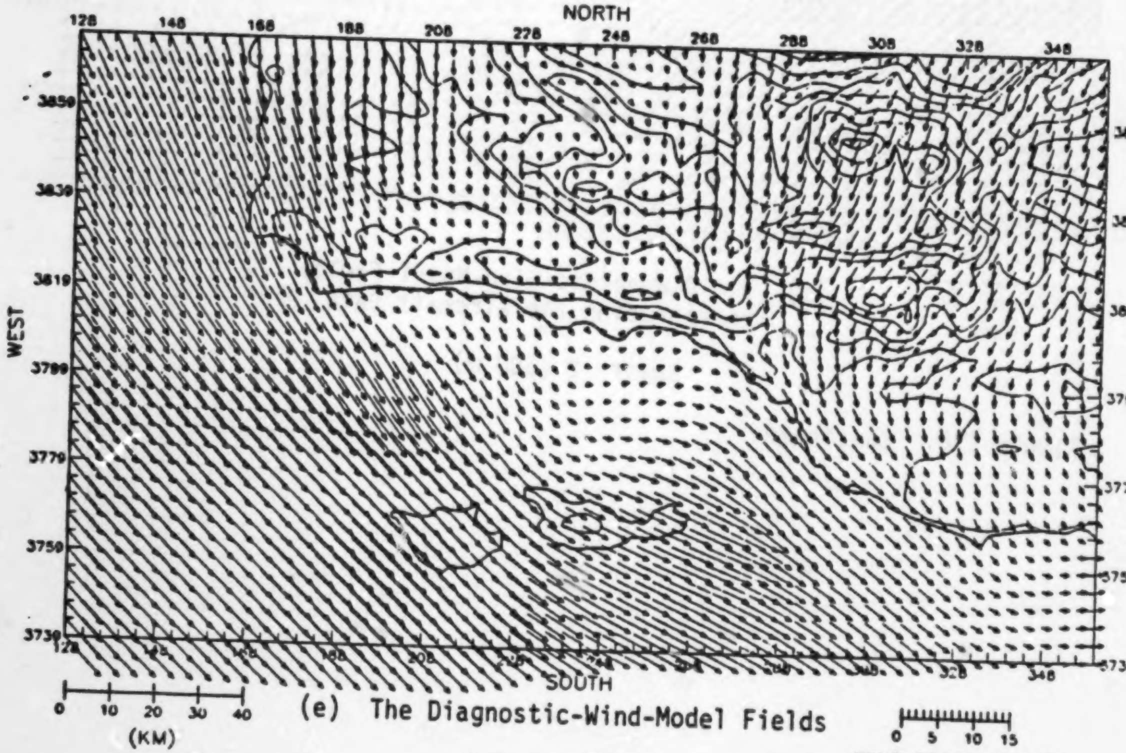
(d) The Averaged Aircraft Observations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0
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(KM)

(e) The Diagnostic-Wind-Model Fields

0
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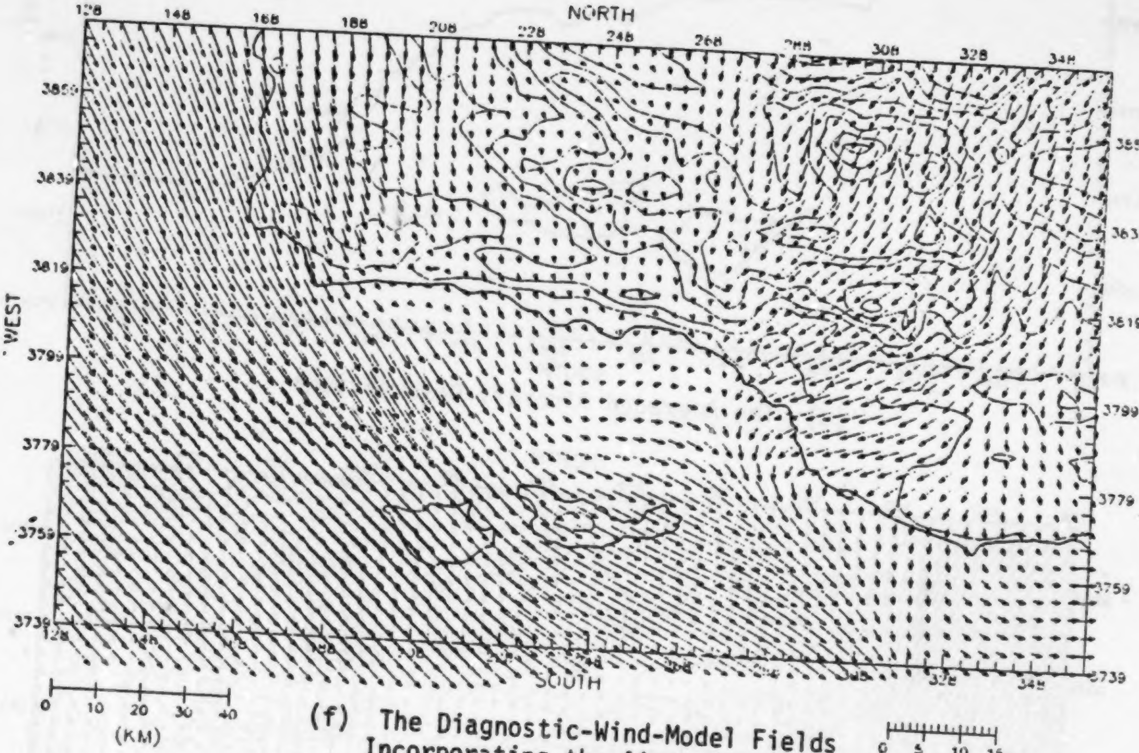
WIND SPEED (M/S)

Layer 2 (100 m)

FIGURE C-8. Continued.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(KM)
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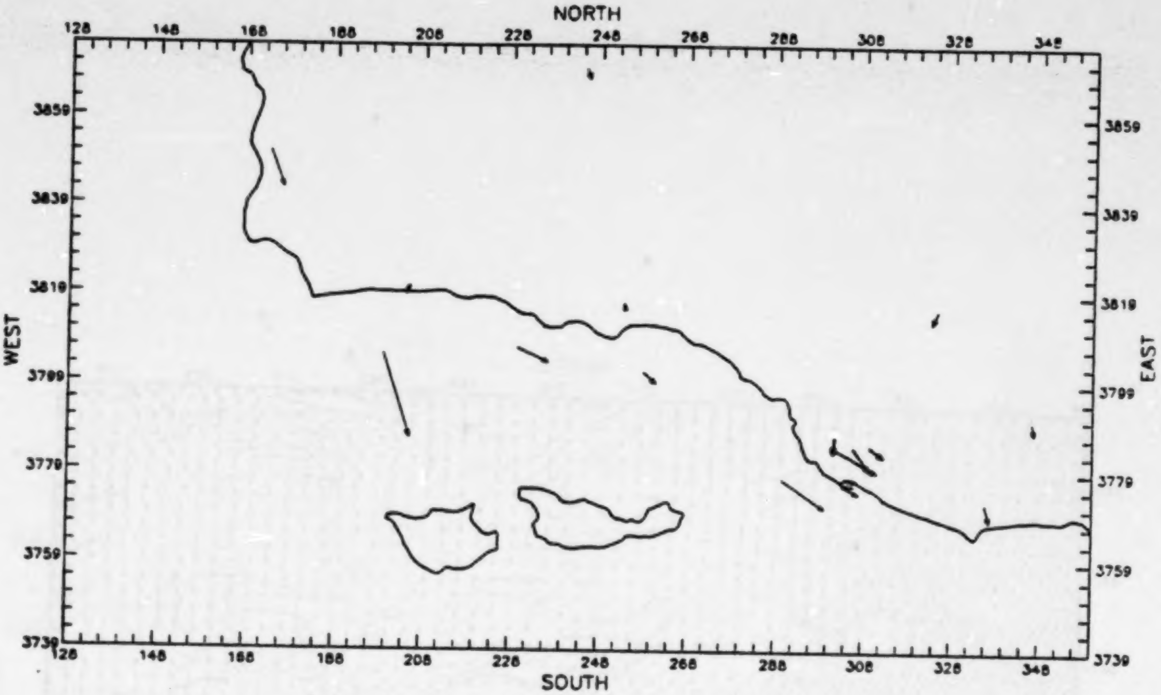
15
WIND SPEED (M/S)

(f) The Diagnostic-Wind-Model Fields Incorporating the Aircraft Data

Layer 2 (100 m)

FIGURE C-8. Continued.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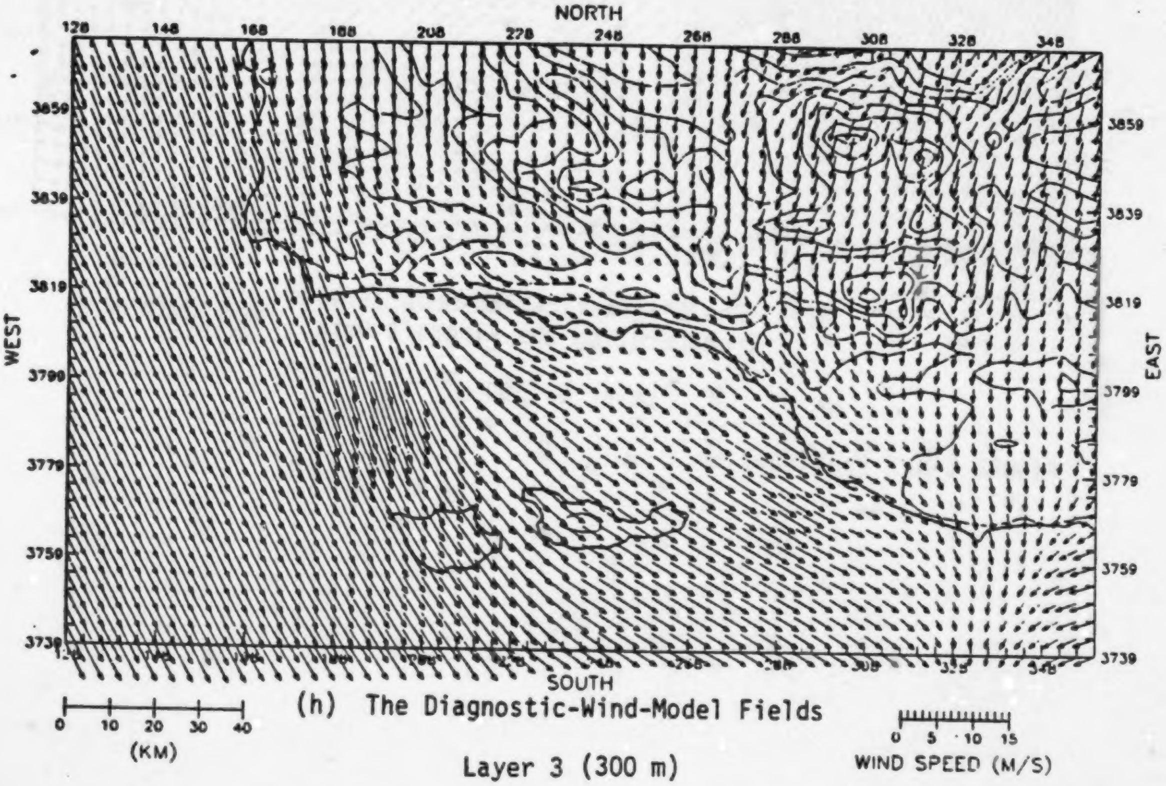
(g) The Averaged Aircraft Observations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(KM)
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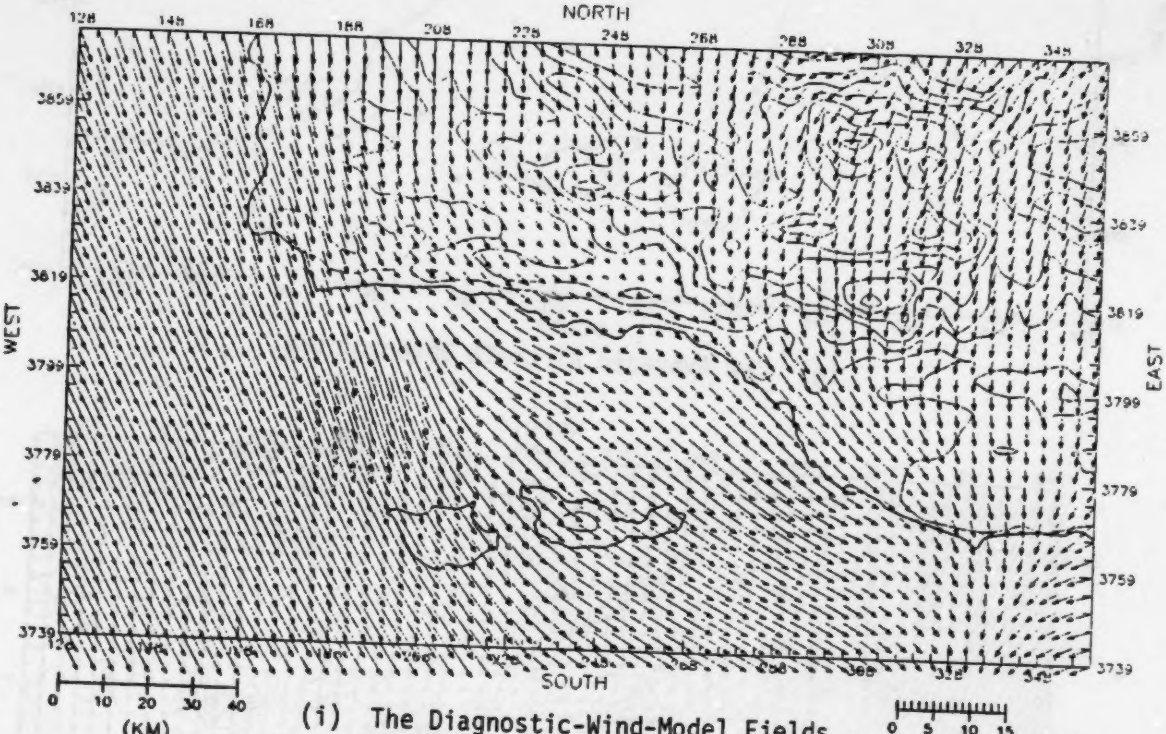
15
WIND SPEED (M/S)

(h) The Diagnostic-Wind-Model Fields

Layer 3 (300 m)

FIGURE C-8. Continued.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40
(KM)
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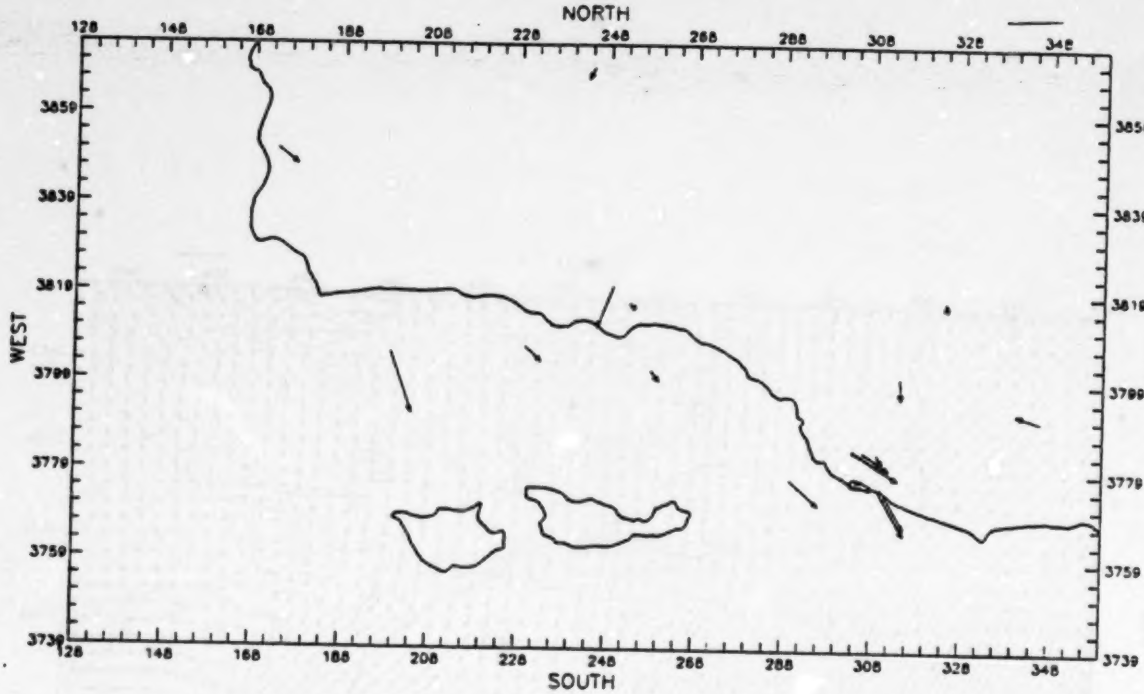
15
WIND SPEED (M/S)

(i) The Diagnostic-Wind-Model Fields Incorporating the Aircraft Data

Layer 3 (300 m)

FIGURE C-8. Continued.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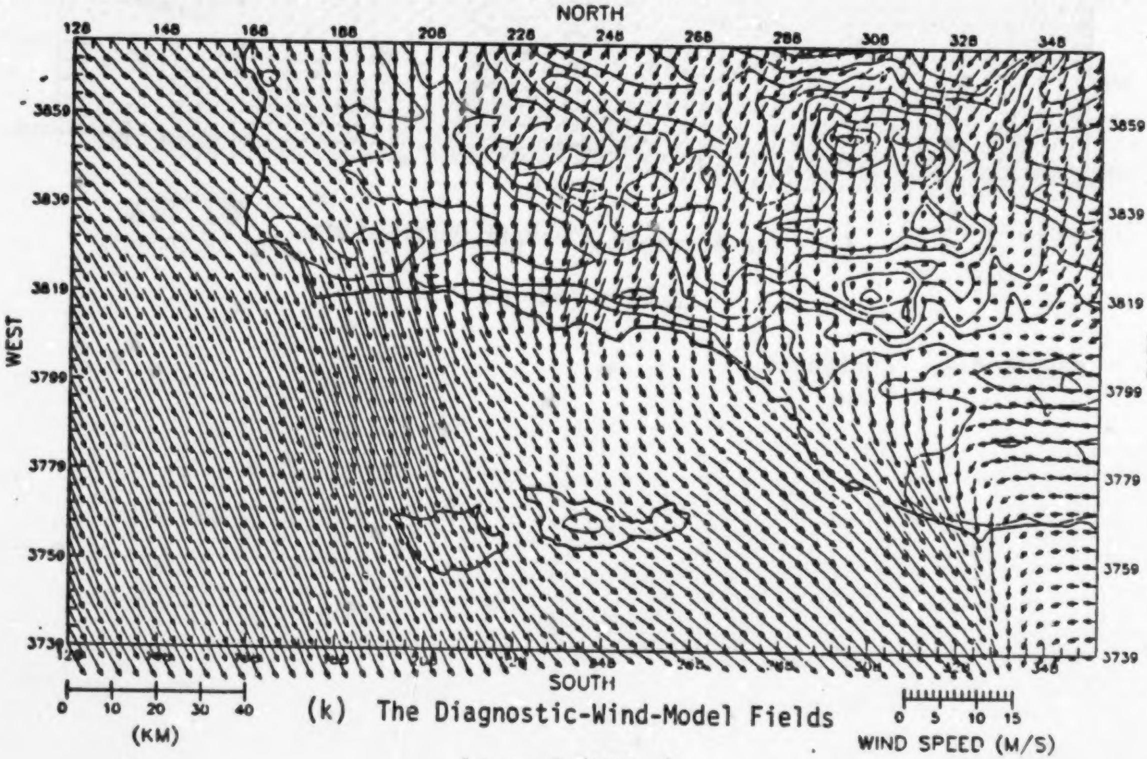
(j) The Averaged Aircraft Observations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EAST
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(KM)
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15
WIND SPEED (M/S)

(k) The Diagnostic-Wind-Model Fields

Layer 4 (600 m)

FIGURE C-8. Continued.

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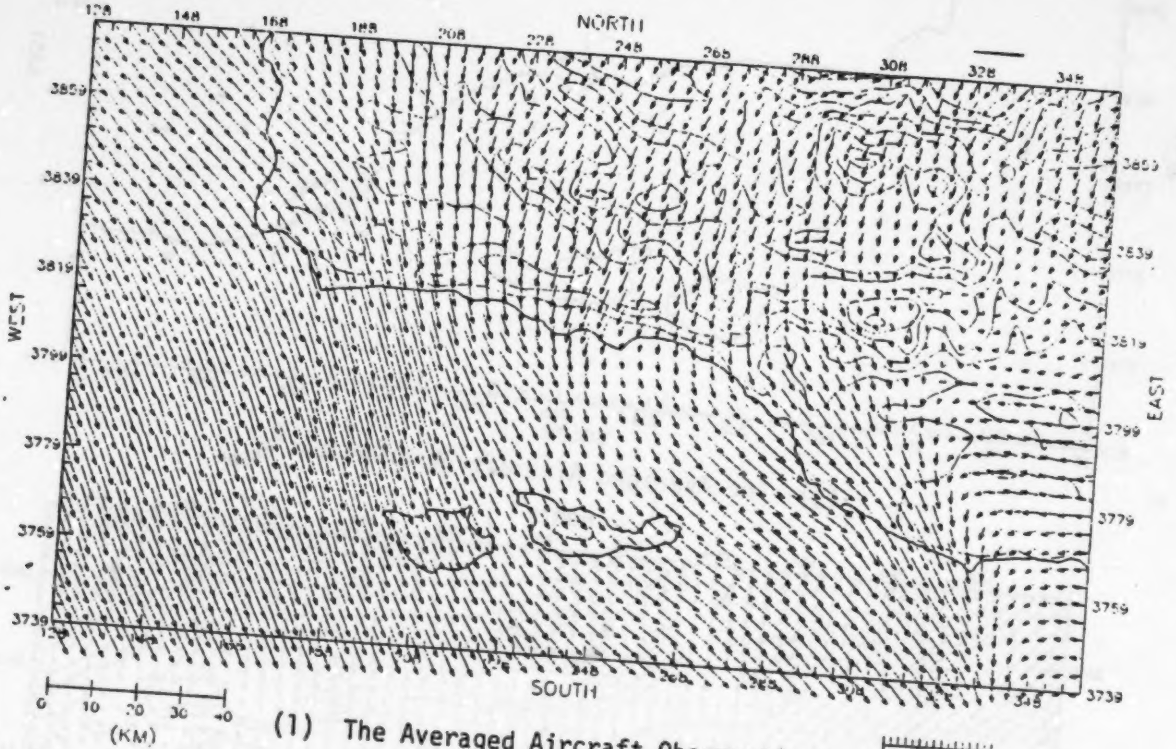
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(KM)
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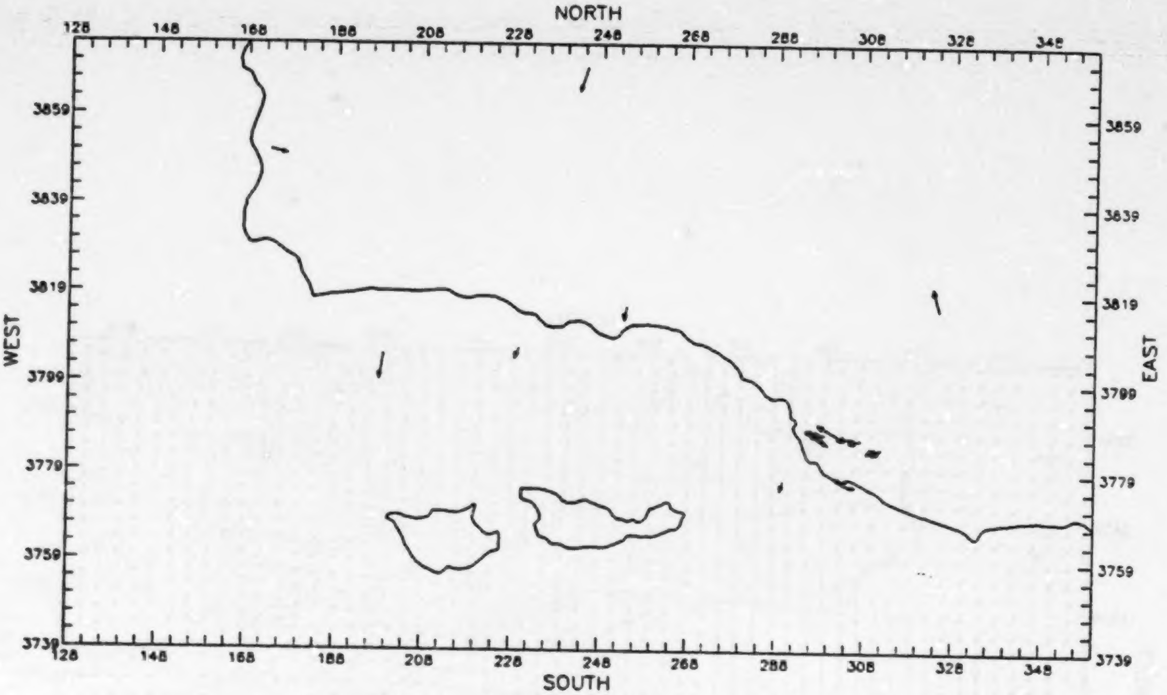
WIND SPEED (M/S)

(1) The Averaged Aircraft Observations

Layer 4 (600 m)

FIGURE C-8. Continued.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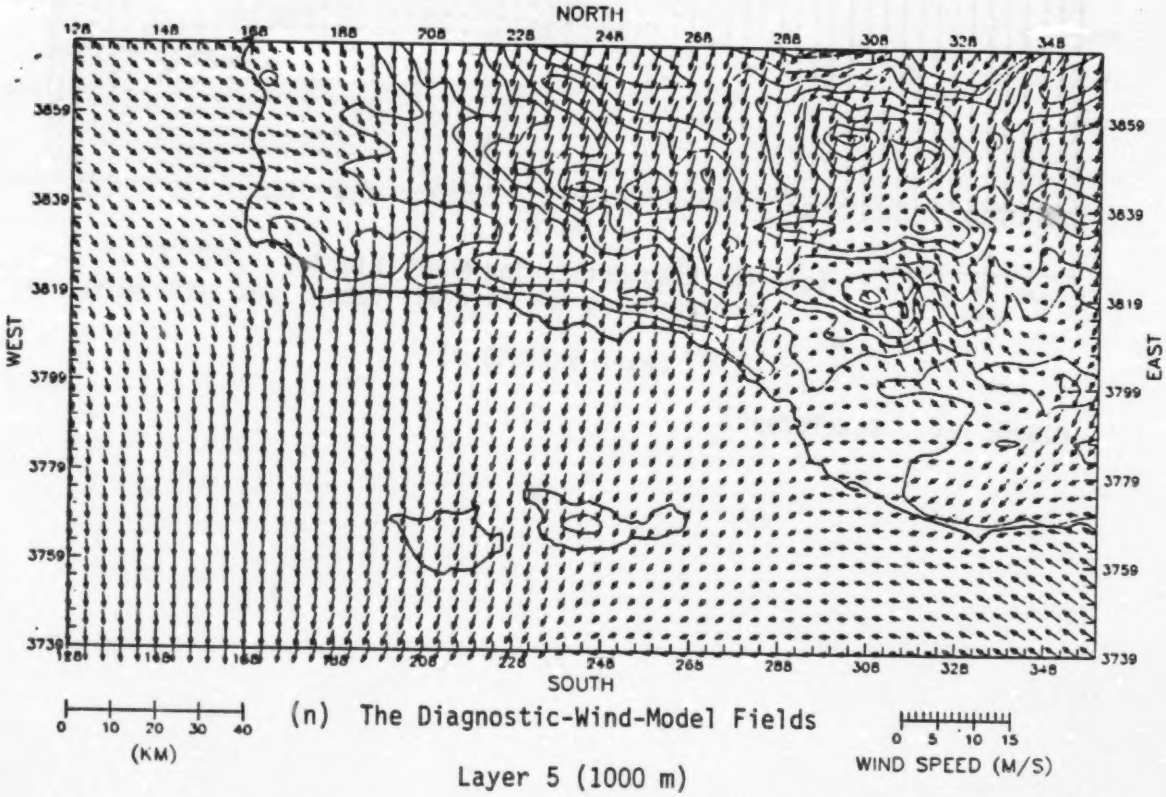
EAST
SOUTH

(m) The Averaged Aircraft Observations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(KM)
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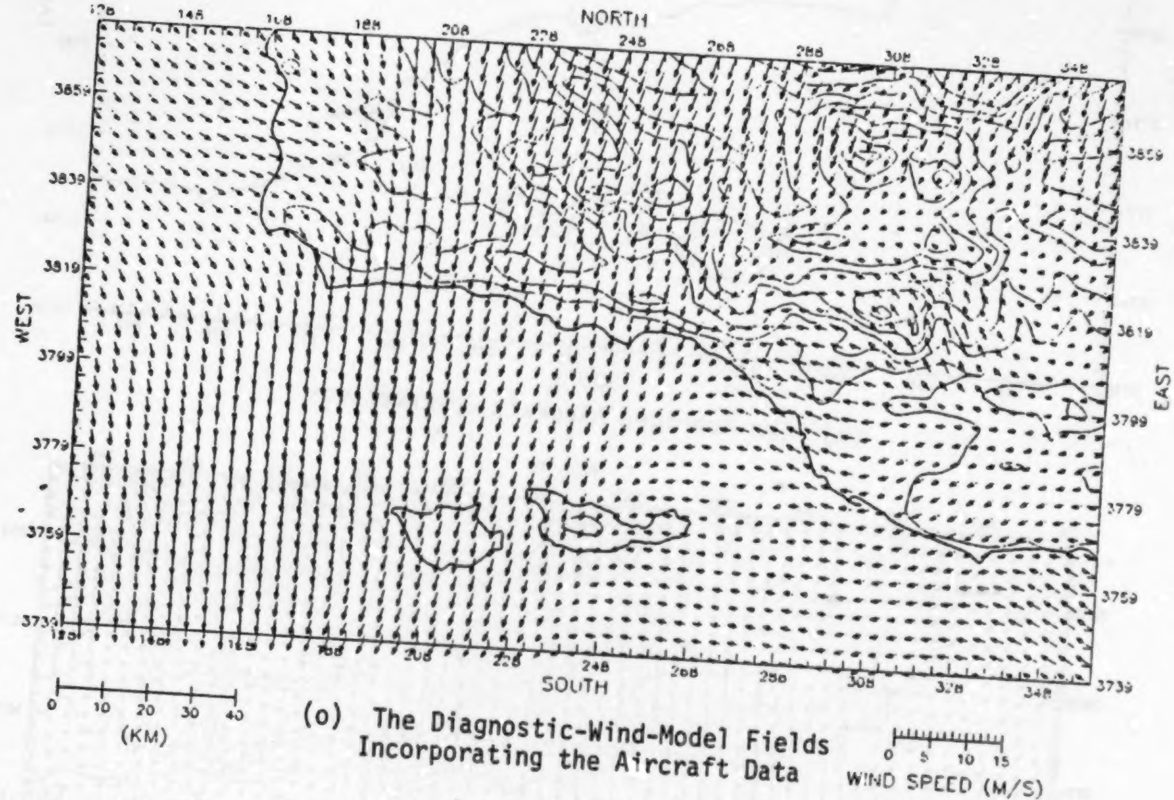
15
WIND SPEED (M/S)

(n) The Diagnostic-Wind-Model Fields

Layer 5 (1000 m)

FIGURE C-8. Continued.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(KM)
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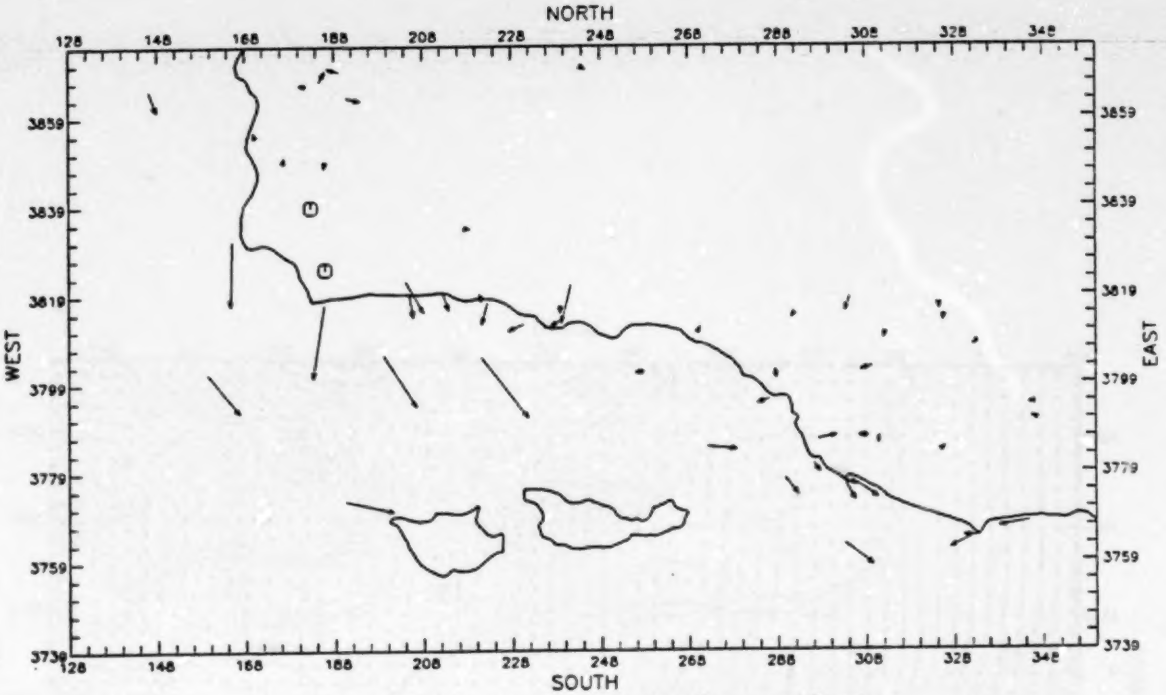
15
WIND SPEED (M/S)

(o) The Diagnostic-Wind-Model Fields Incorporating the Aircraft Data

Layer 5 (1000 m)

FIGURE C-8. Concluded.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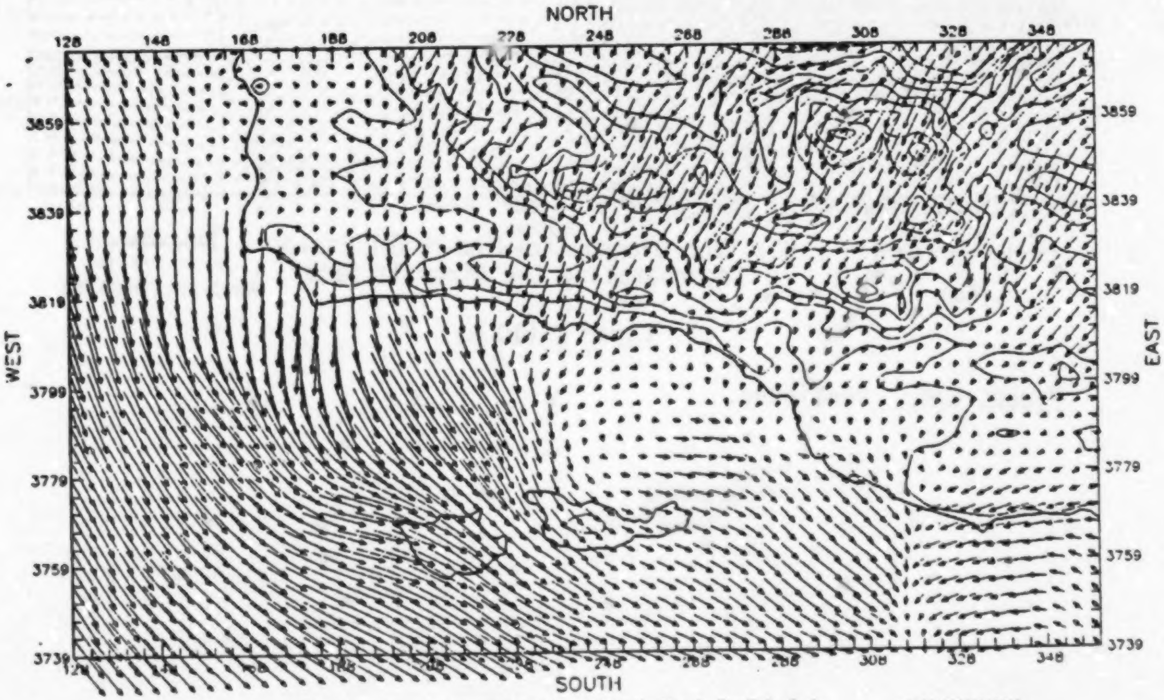
EAST
SOUTH

(a) The Averaged Aircraft Observations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EAST
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(KM)
0
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15
WIND SPEED (M/S)

(b) The Diagnostic-Wind-Model Fields

Layer 1 (10 m)

FIGURE C-9. Comparison of averaged aircraft observations and diagnostic-wind-model fields with and without aircraft data for 2100 PDT. The aircraft observations are plotted in boldface.

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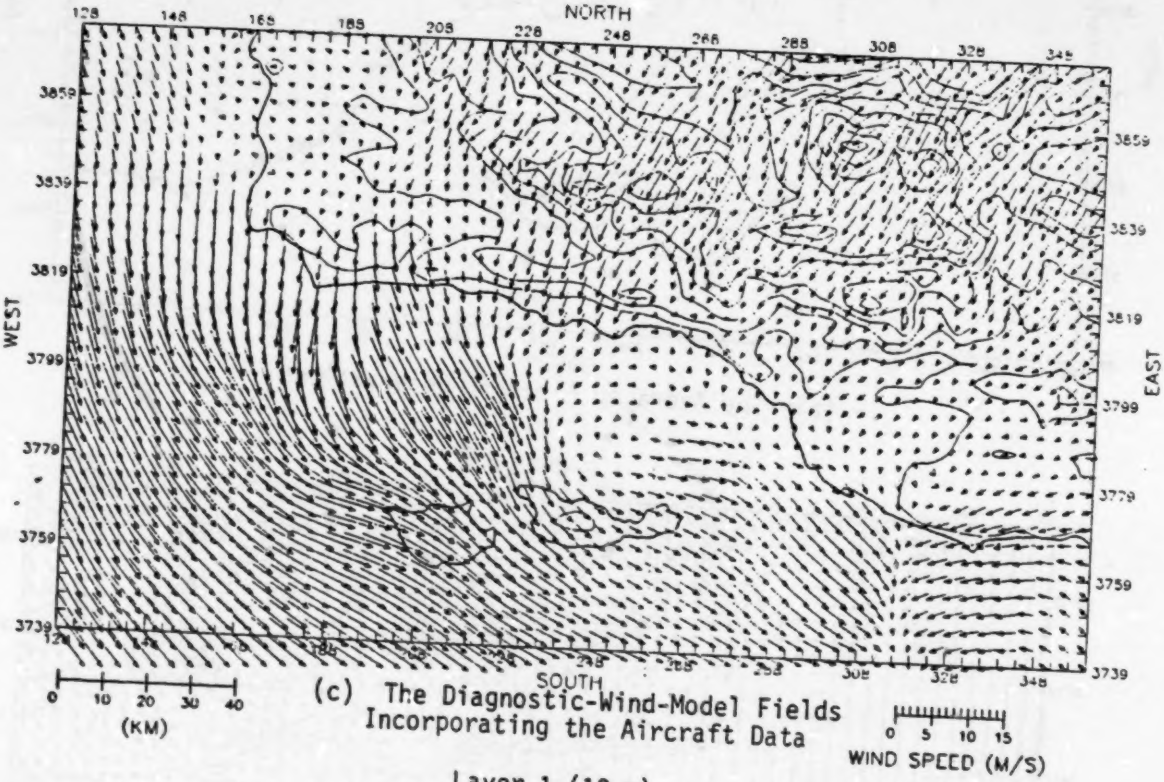
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(KM)
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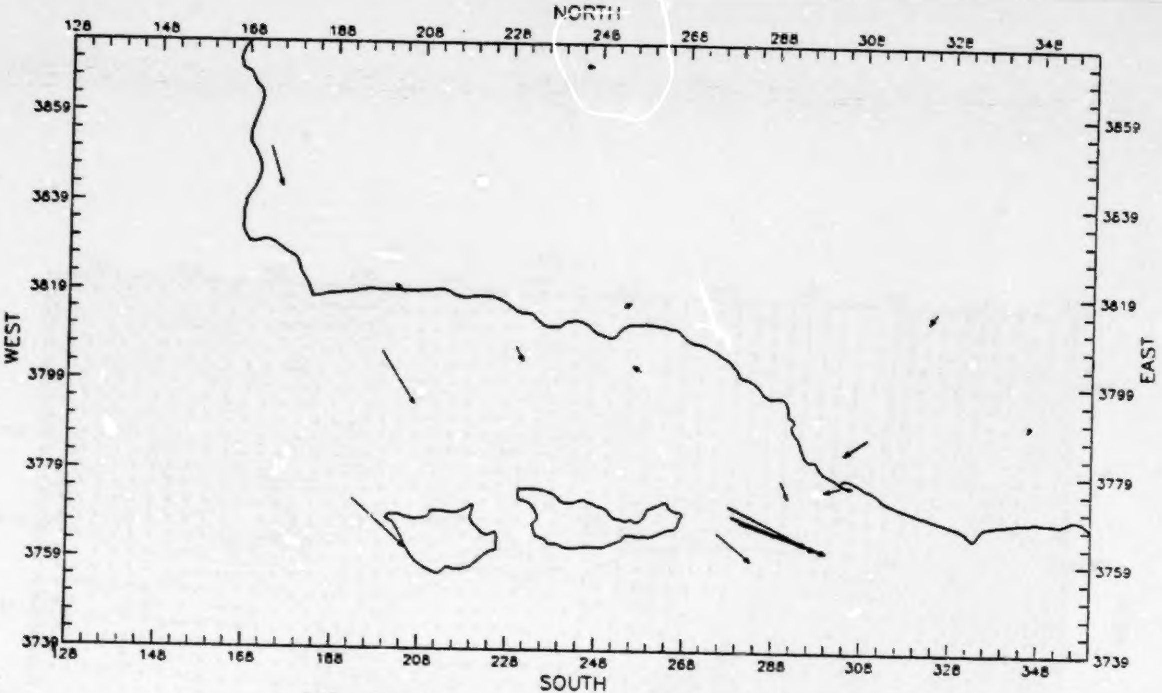
WIND SPEED (M/S)

(c) The Diagnostic-Wind-Model Fields Incorporating the Aircraft Data

Layer 1 (10 m)

FIGURE C-9. Continued.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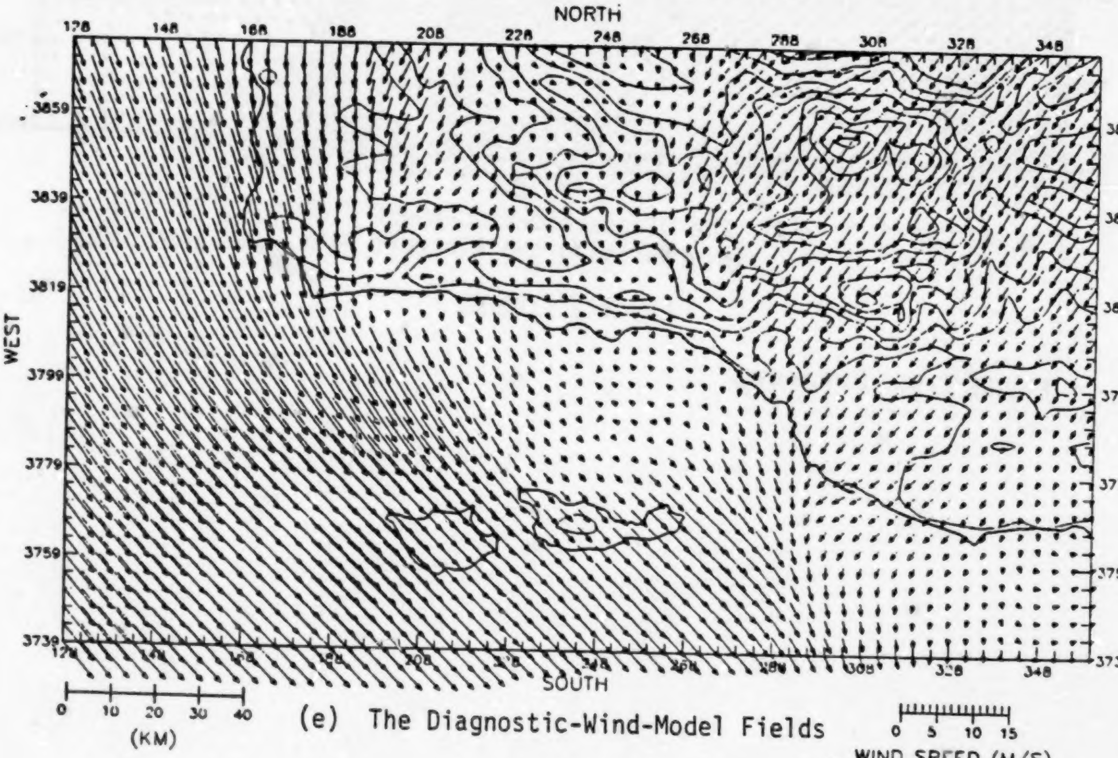
(d) The Averaged Aircraft Observations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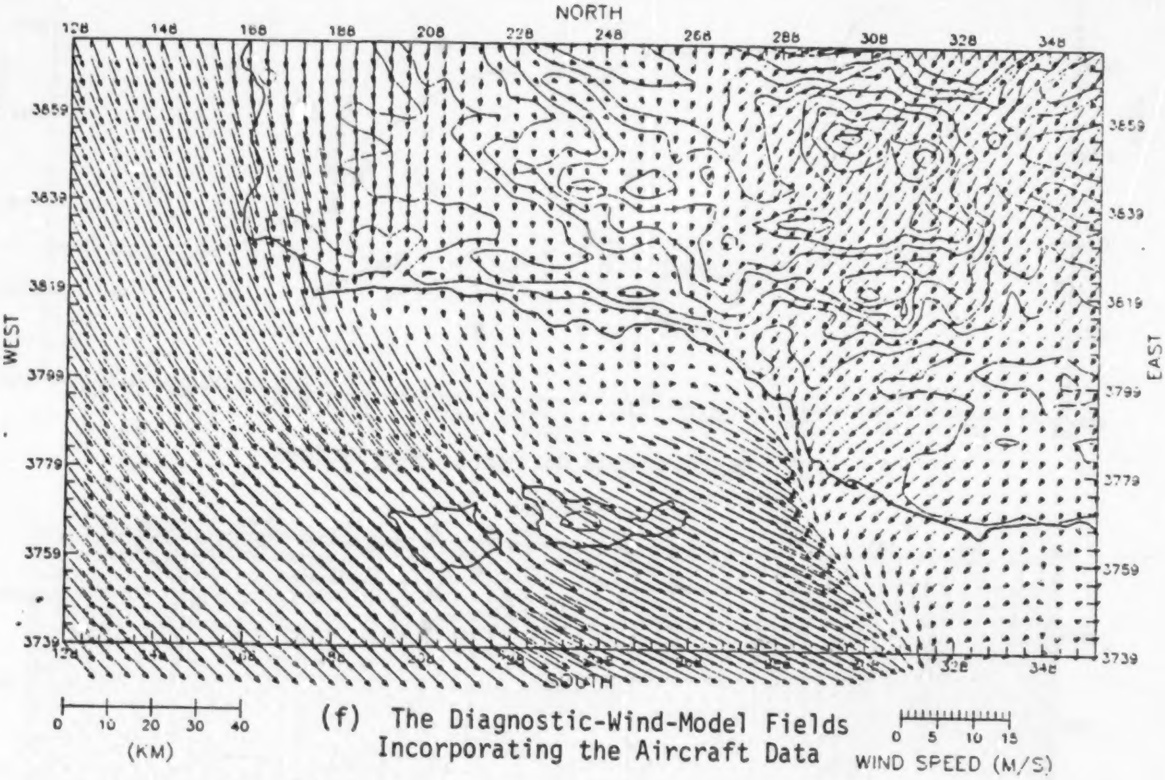
3799
3779
3759
3739
0 10 20 30 40
(KM)
0 5 10 15
WIND SPEED (M/S)

(e) The Diagnostic-Wind-Model Fields

Layer 2 (100 m)

FIGURE C-9. Continued.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(KM)
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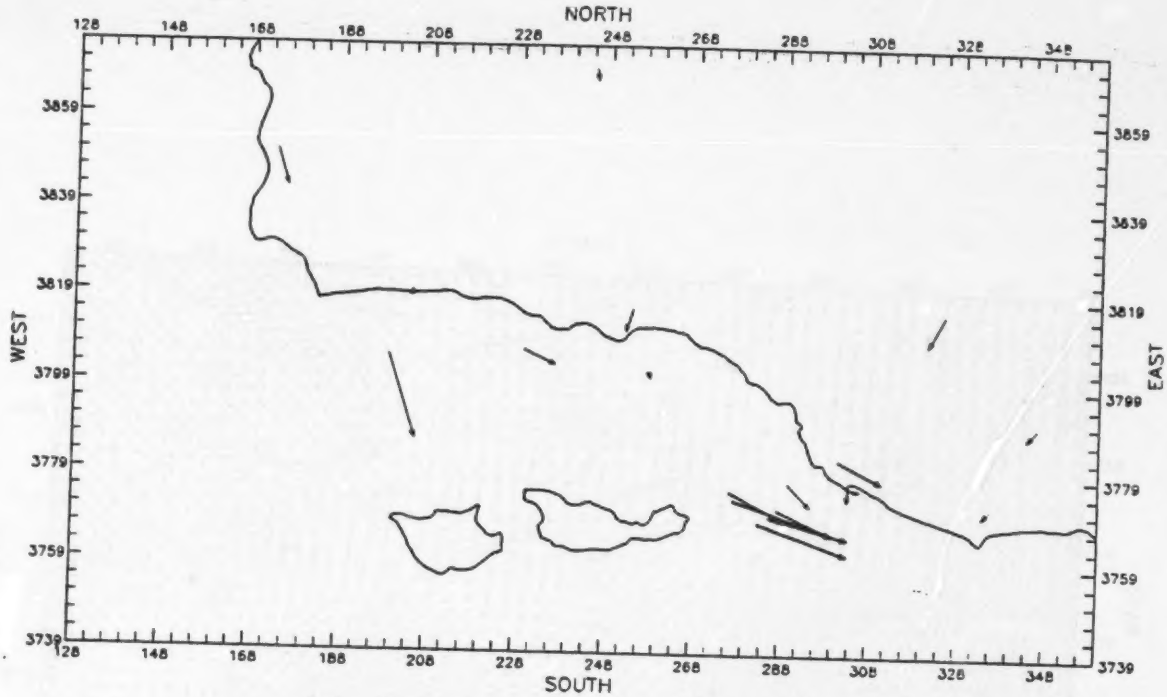
WIND SPEED (M/S)

(f) The Diagnostic-Wind-Model Fields Incorporating the Aircraft Data

Layer 2 (100 m)

FIGURE C-9. Continued.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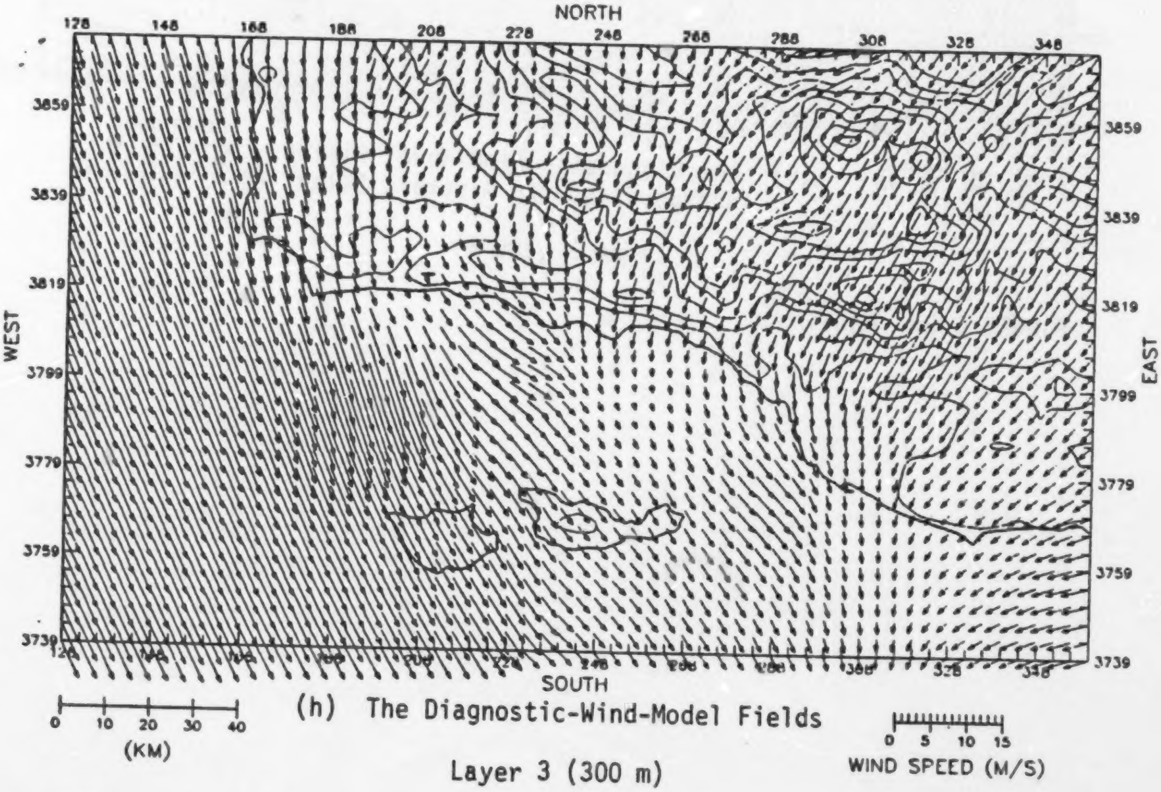
SOUTH

(g) The Averaged Aircraft Observations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(KM)
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WIND SPEED (M/S)

(h) The Diagnostic-Wind-Model Fields

Layer 3 (300 m)

FIGURE C-9. Continued.

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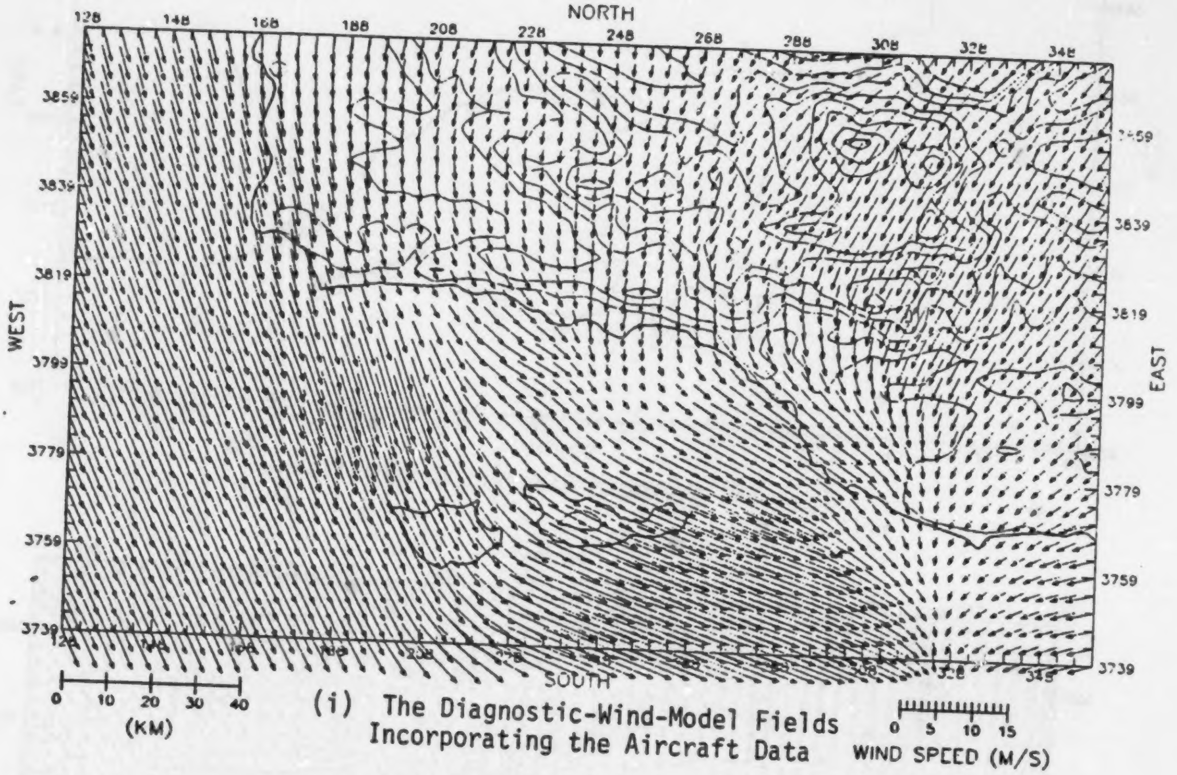
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(KM)
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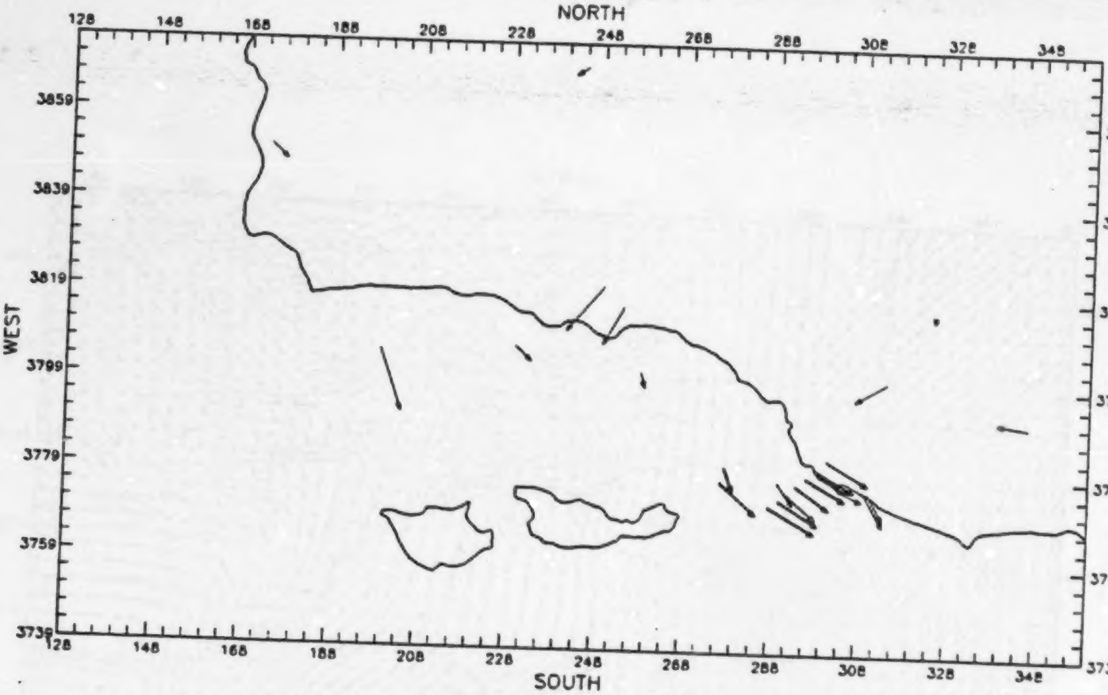
WIND SPEED (M/S)

(i) The Diagnostic-Wind-Model Fields Incorporating the Aircraft Data

Layer 3 (300 m)

FIGURE C-9. Continued.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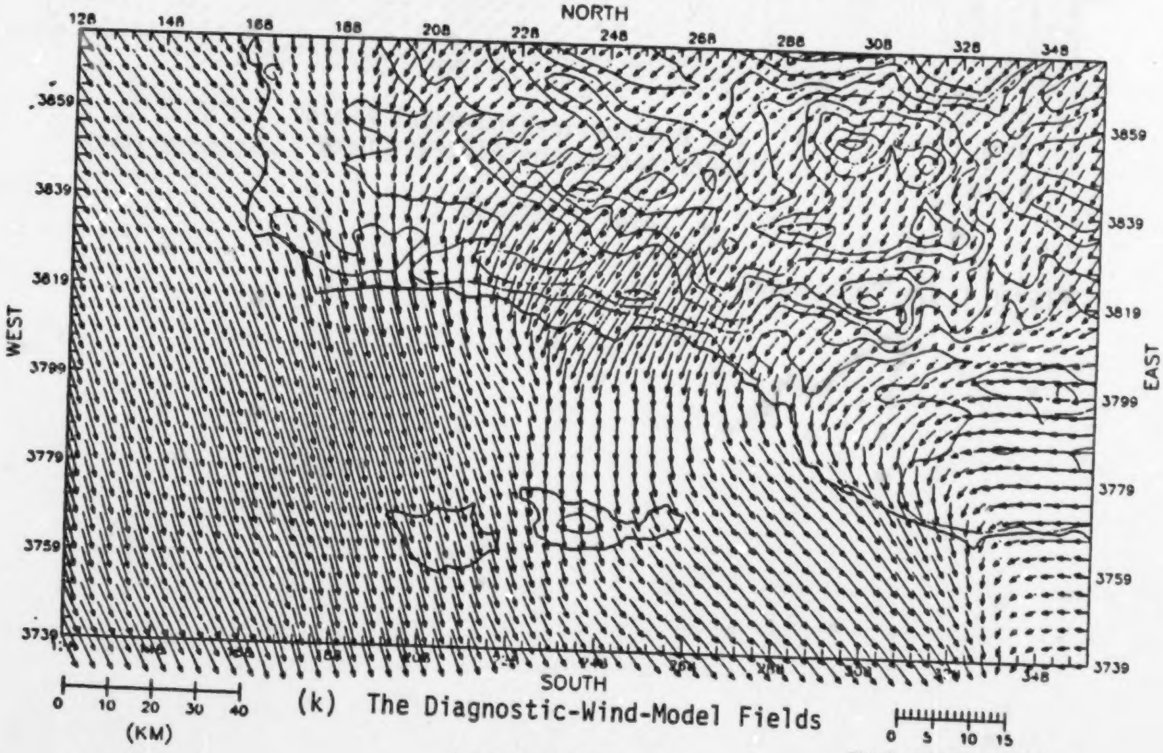
(j) The Averaged Aircraft Observations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(KM)
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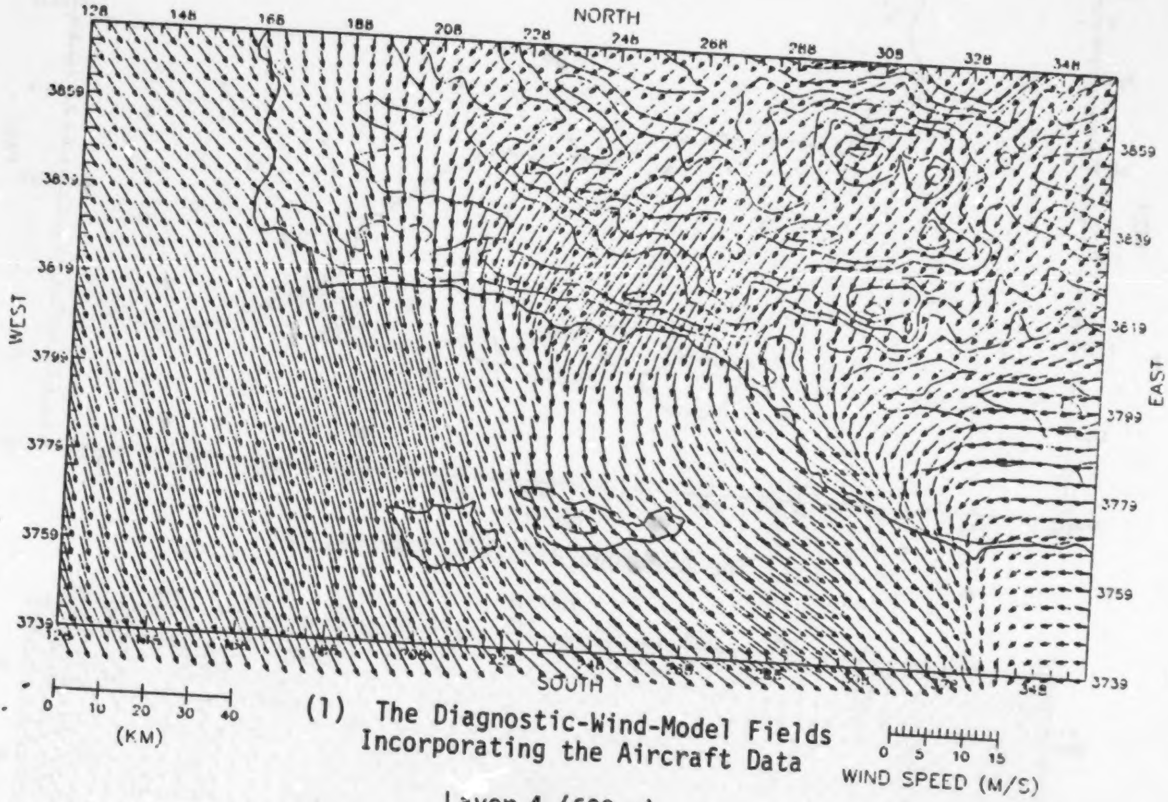
WIND SPEED (M/S)

(k) The Diagnostic-Wind-Model Fields

Layer 4 (600 m)

FIGURE C-9. Continued.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(KM)
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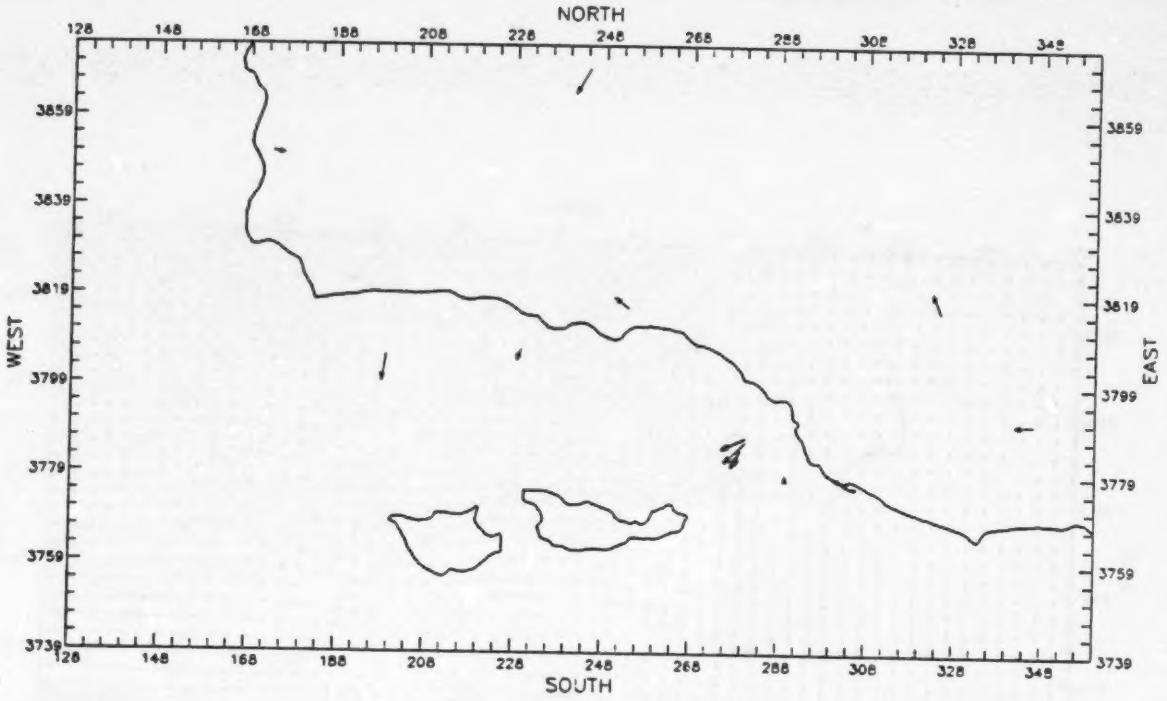
WIND SPEED (M/S)

(1) The Diagnostic-Wind-Model Fields
Incorporating the Aircraft Data

Layer 4 (600 m)

FIGURE C-9. Continued.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WEST
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EAST
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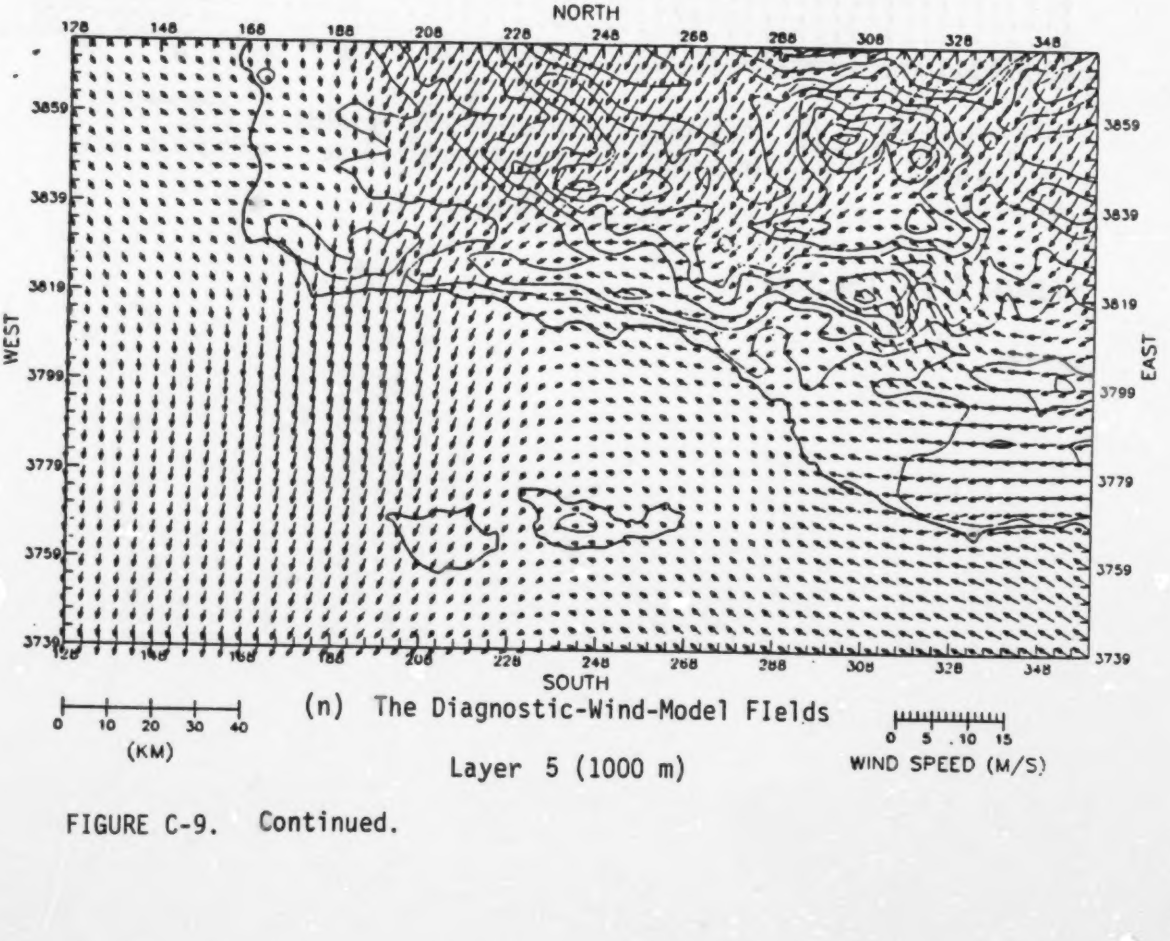
128 148 168 188 208 228 248 268 288 308 328 348
SOUTH

(m) The Averaged Aircraft Observations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EAST
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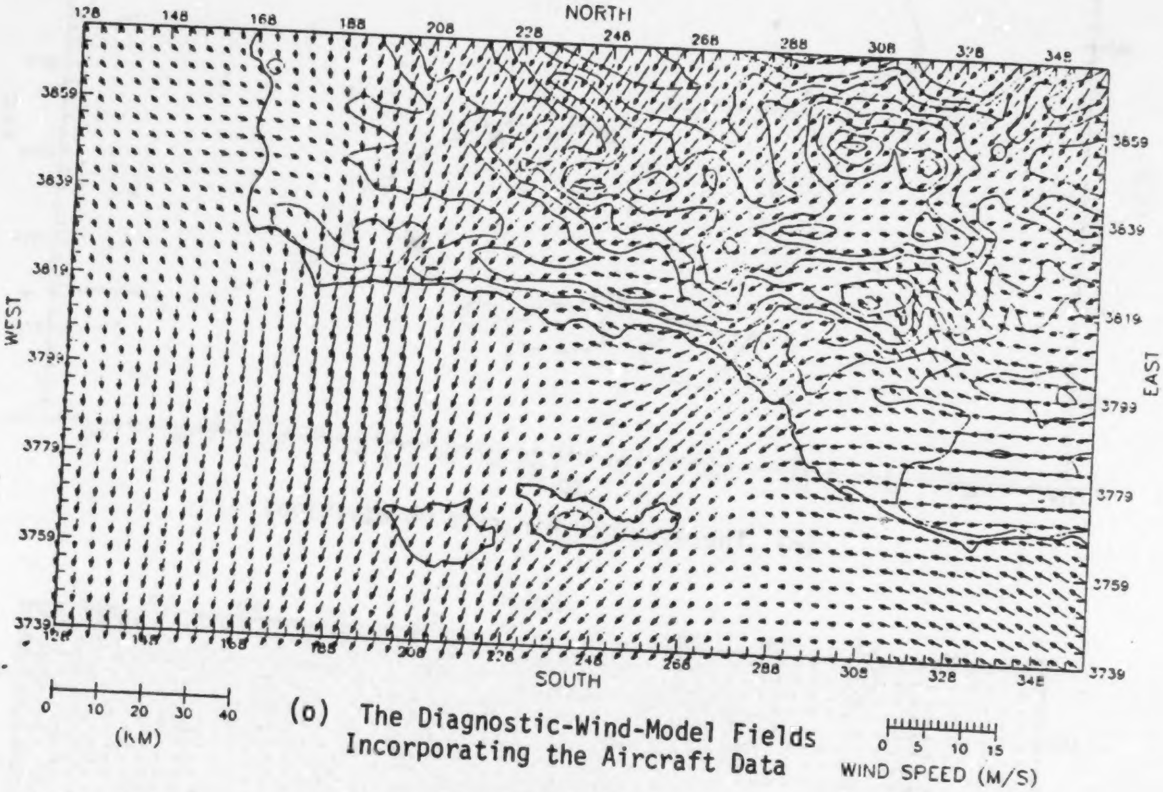
128 148 168 188 208 228 248 268 288 308 328 348
SOUTH
0 10 20 30 40
(KM)
0 5 10 15
WIND SPEED (M/S)

(n) The Diagnostic-Wind-Model Fields

Layer 5 (1000 m)

FIGURE C-9. Continued.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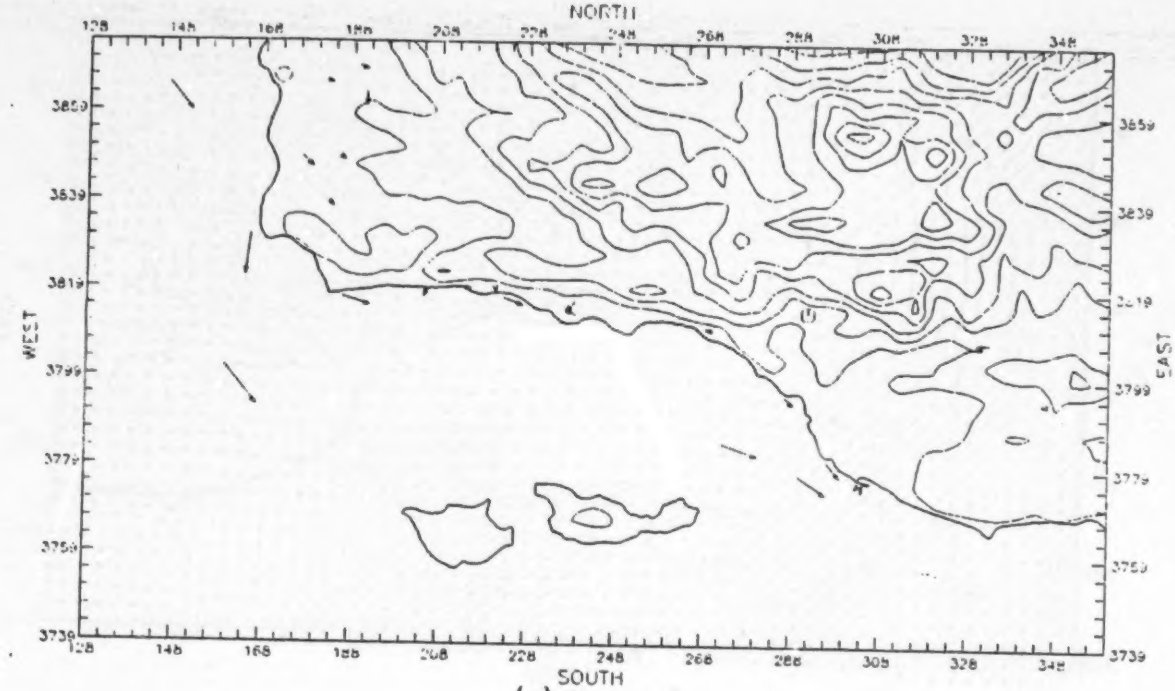
168
188
208
228
248
268
288
308
328
348
3859
3839
3819
3799
3779
3759
3739
WEST
EAST
SOUTH
0
10
20
30
40
(KM)
0
5
10
15
WIND SPEED (M/S)

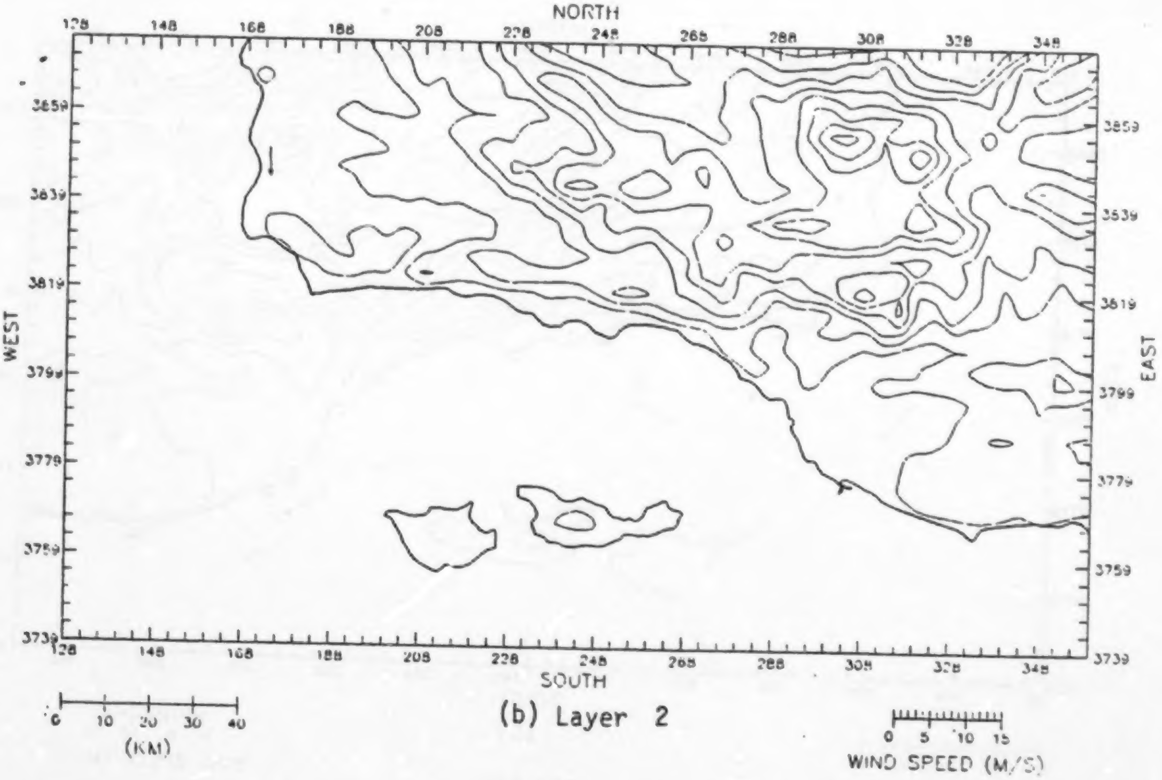
(o) The Diagnostic-Wind-Model Fields Incorporating the Aircraft Data

Layer 5 (1000 m)

FIGURE C-9. Concluded.

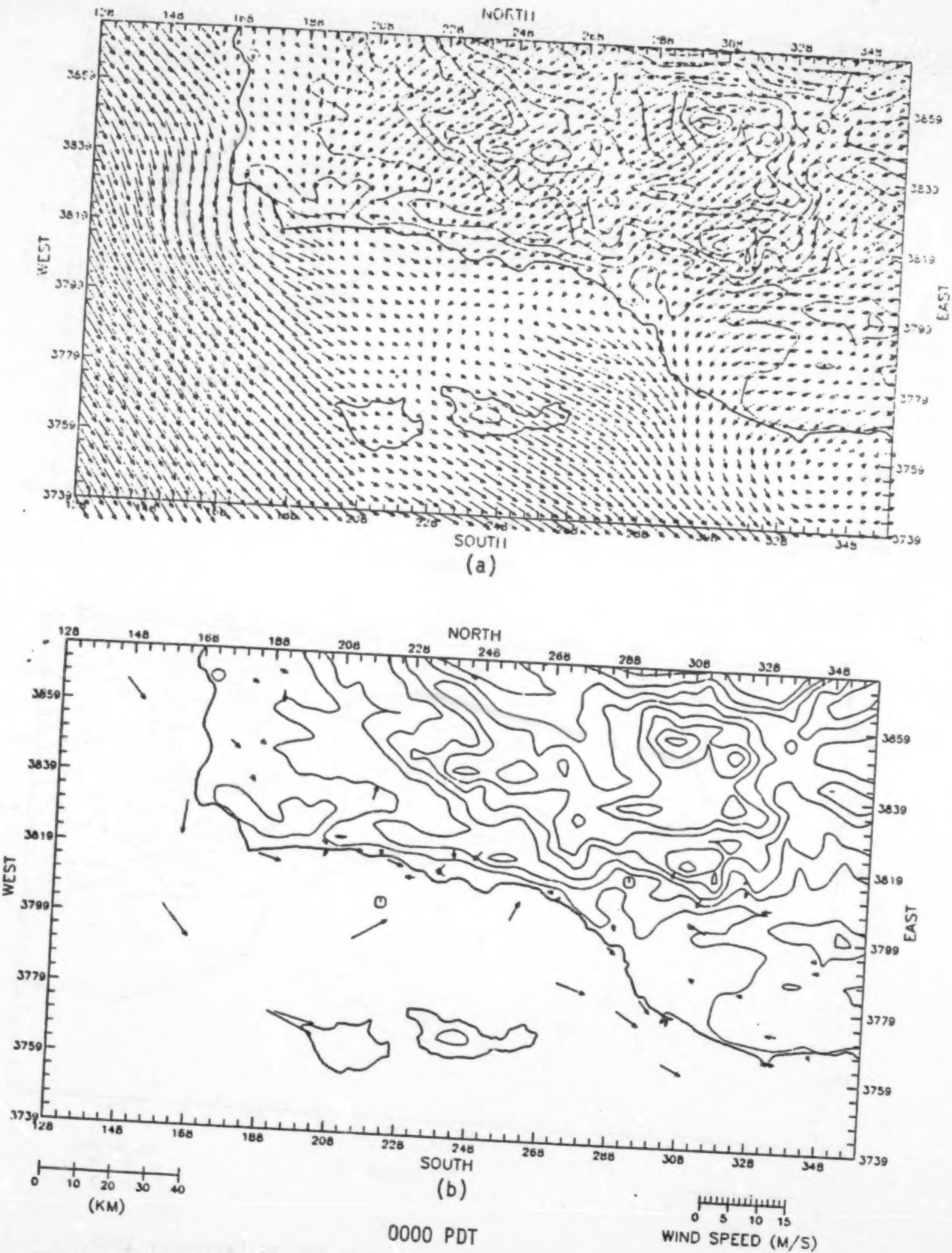

NORTH
128
148
168
188
208
228
248
268
288
308
328
348
3859
3839
3819
3799
3779
3759
3739
WEST
EAST
SOUTH

(a) Layer 1


NORTH
128
148
168
188
208
228
248
268
288
308
328
348
3859
3839
3819
3799
3779
3759
3739
WEST
EAST
SOUTH
0
10
20
30
40
(KM)
0
5
10
15
WIND SPEED (M/S)

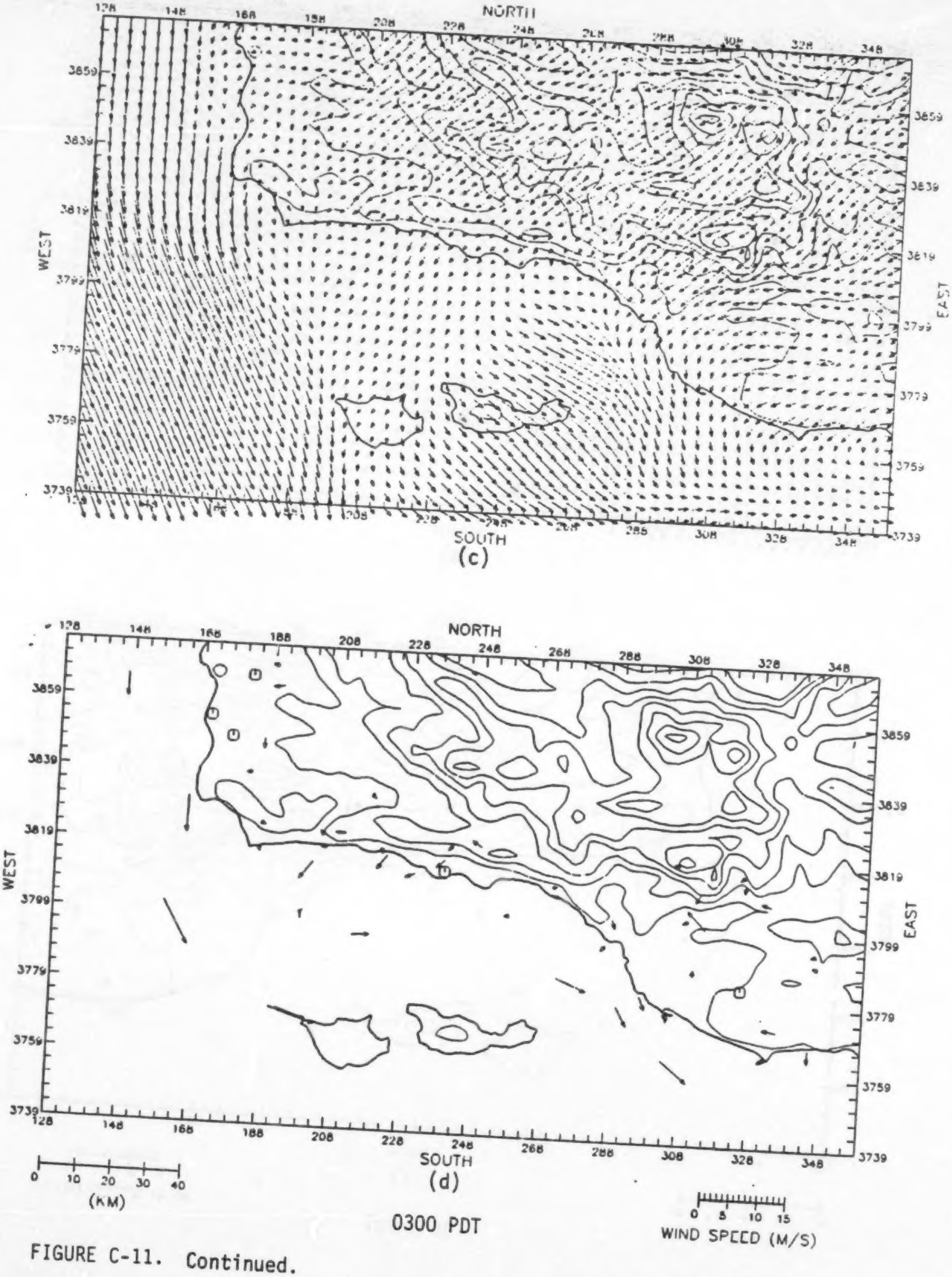
(b) Layer 2

FIGURE C-10. Routine observations for 0000 PDT 23 September 1985.



NORTH
SOUTH
WEST
EAST
128
148
168
188
208
228
248
268
288
308
328
348
3859
3839
3819
3799
3779
3759
3739
(a)
(b)
0
10
20
30
40
(KM)
0
5
10
15
WIND SPEED (M/S)
0000 PDT

FIGURE C-11. RTN1 surface wind fields and corresponding observation plots for 23 September 1985. The observation plots include both routine and supplementary data.


NORTH
SOUTH
WEST
EAST
128
148
168
188
208
228
248
268
288
308
328
348
3739
3759
3779
3799
3819
3839
3859
0
10
20
30
40
(KM)
0
5
10
15
WIND SPEED (M/S)

(c)

(d)

0300 PDT

FIGURE C-11. Continued.

89024

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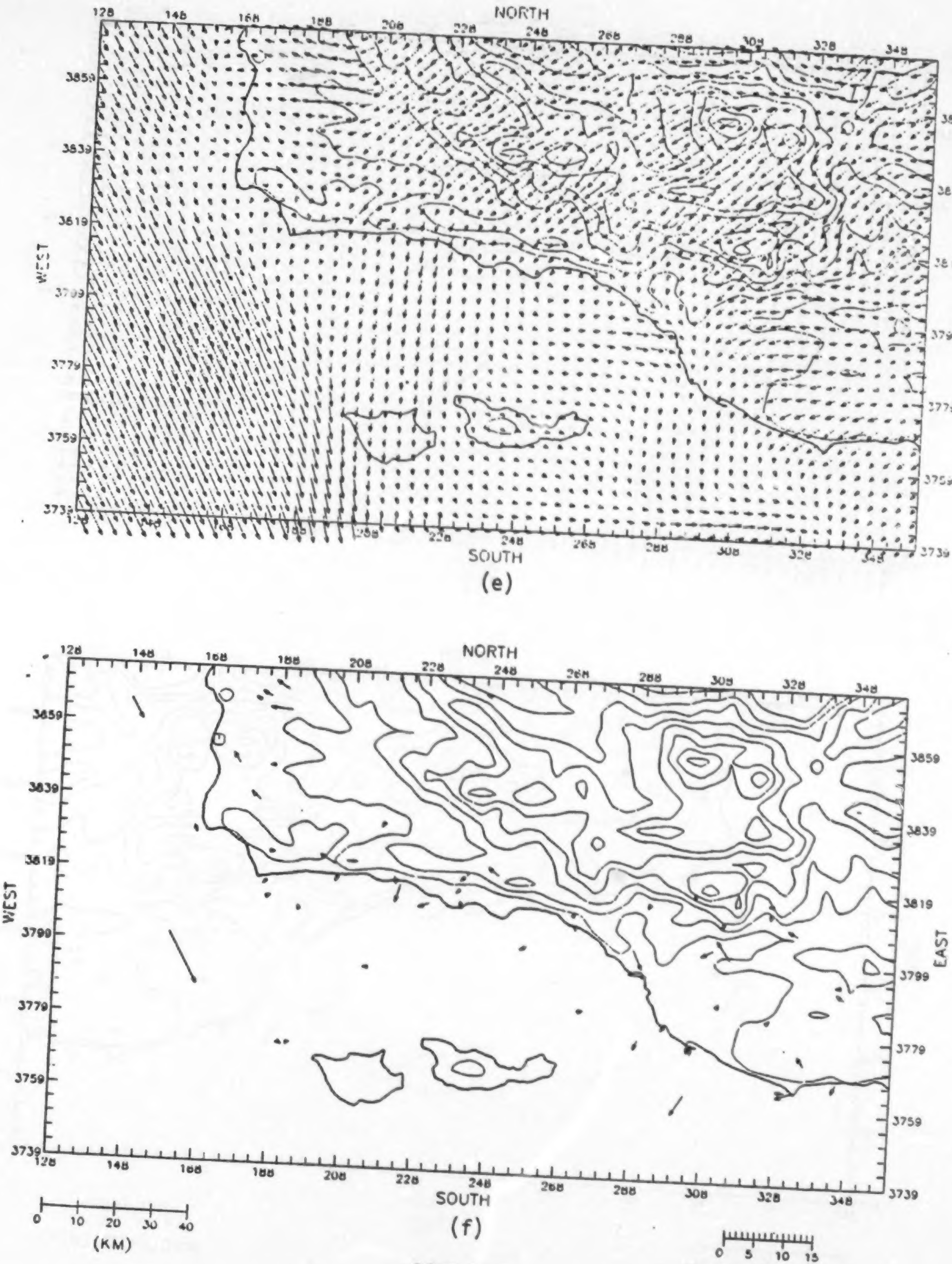
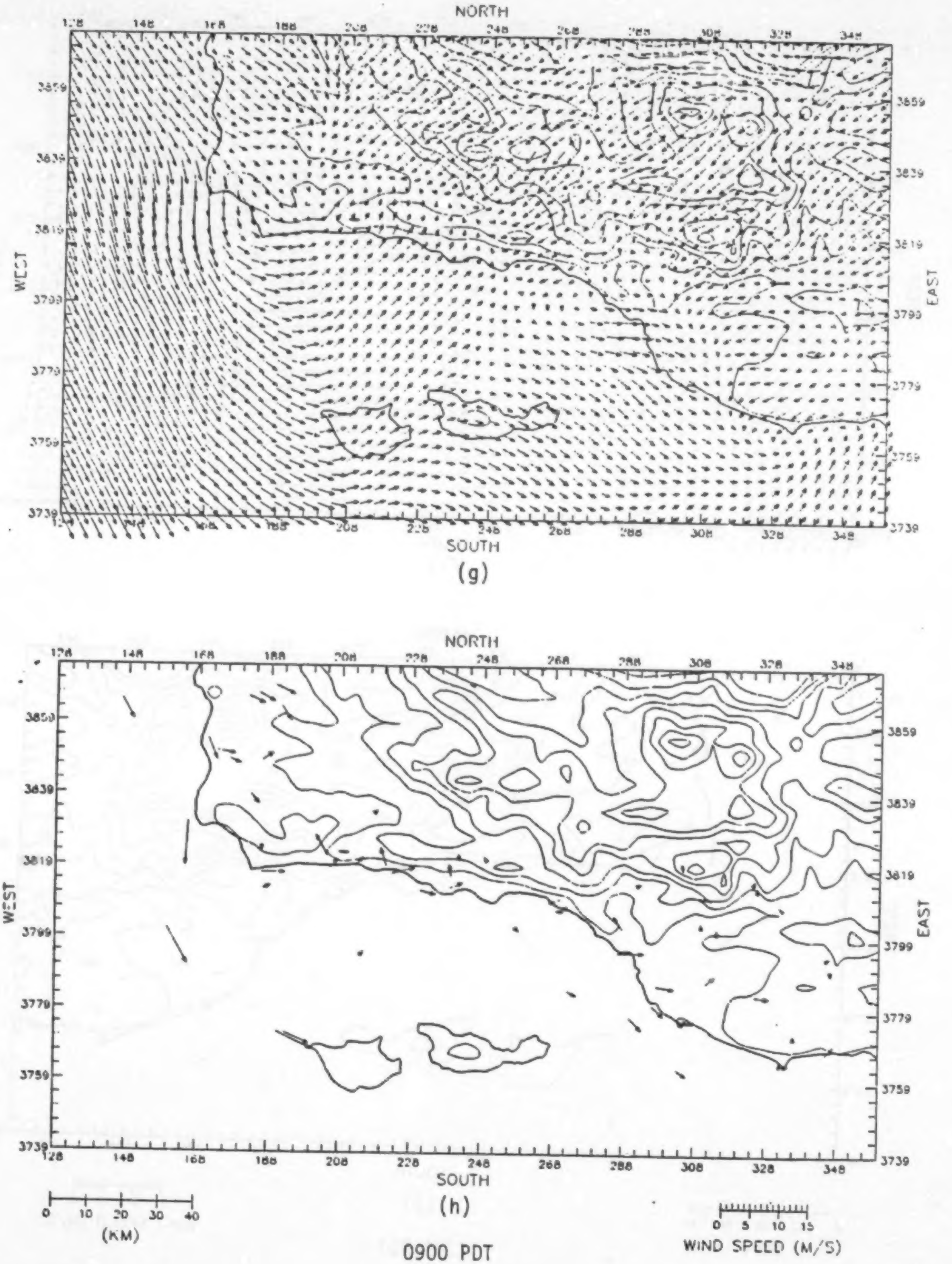

NORTH
128
148
168
188
208
228
248
268
288
308
328
348
WEST
EAST
SOUTH
3739
3759
3779
3799
3819
3839
3859
(e)
(f)
0
10
20
30
40
(KM)
0
5
10
15
WIND SPEED (M/S)

0600 PDT

FIGURE C-11. Continued.

89024

87182

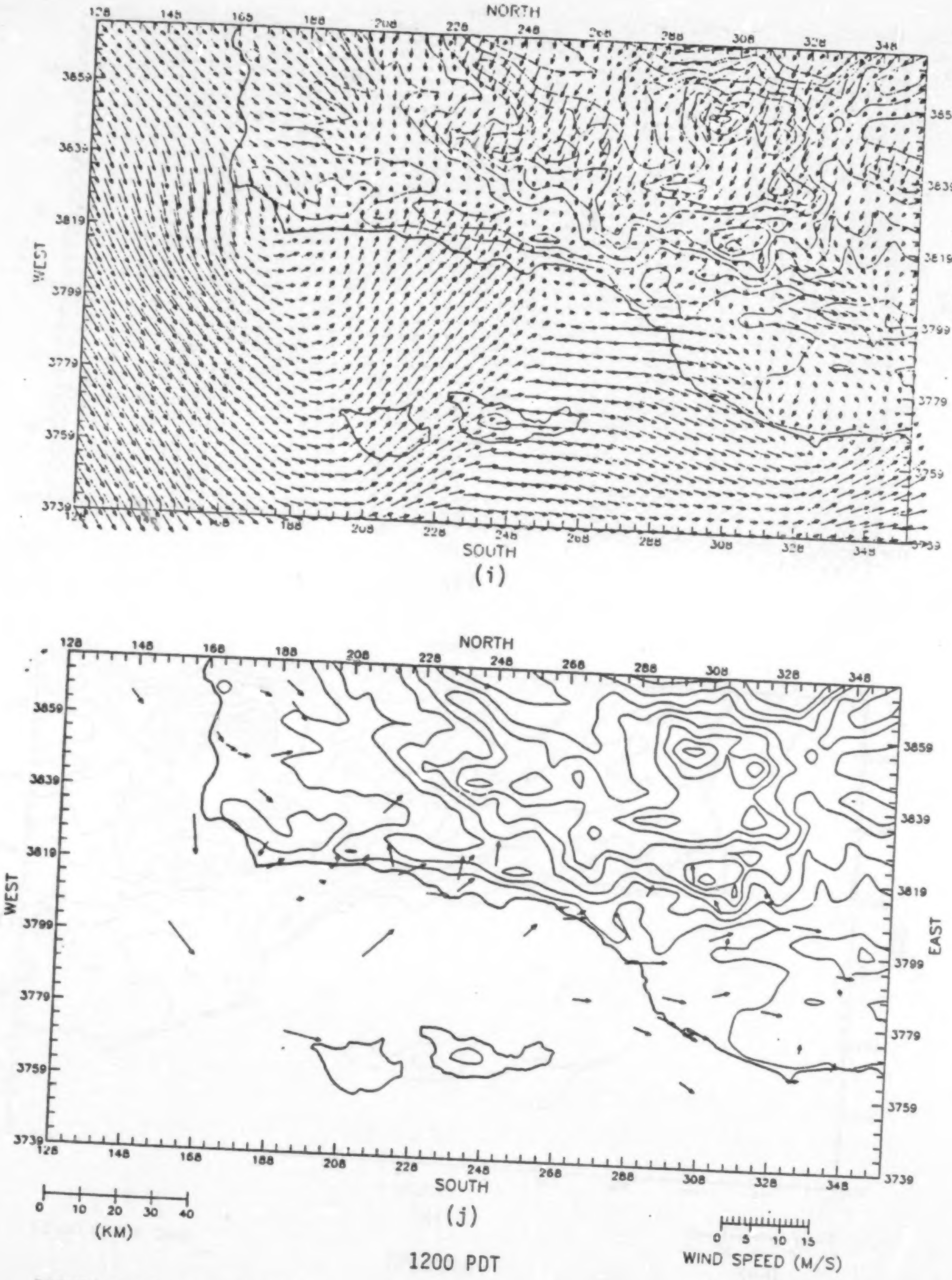

NORTH
128
148
168
188
208
228
248
268
288
308
328
348
3859
3839
3819
3799
3779
3759
3739
WEST
EAST
SOUTH
(g)
(h)
0
10
20
30
40
(KM)
0
5
10
15
WIND SPEED (M/S)

0900 PDT

FIGURE C-11. Continued.

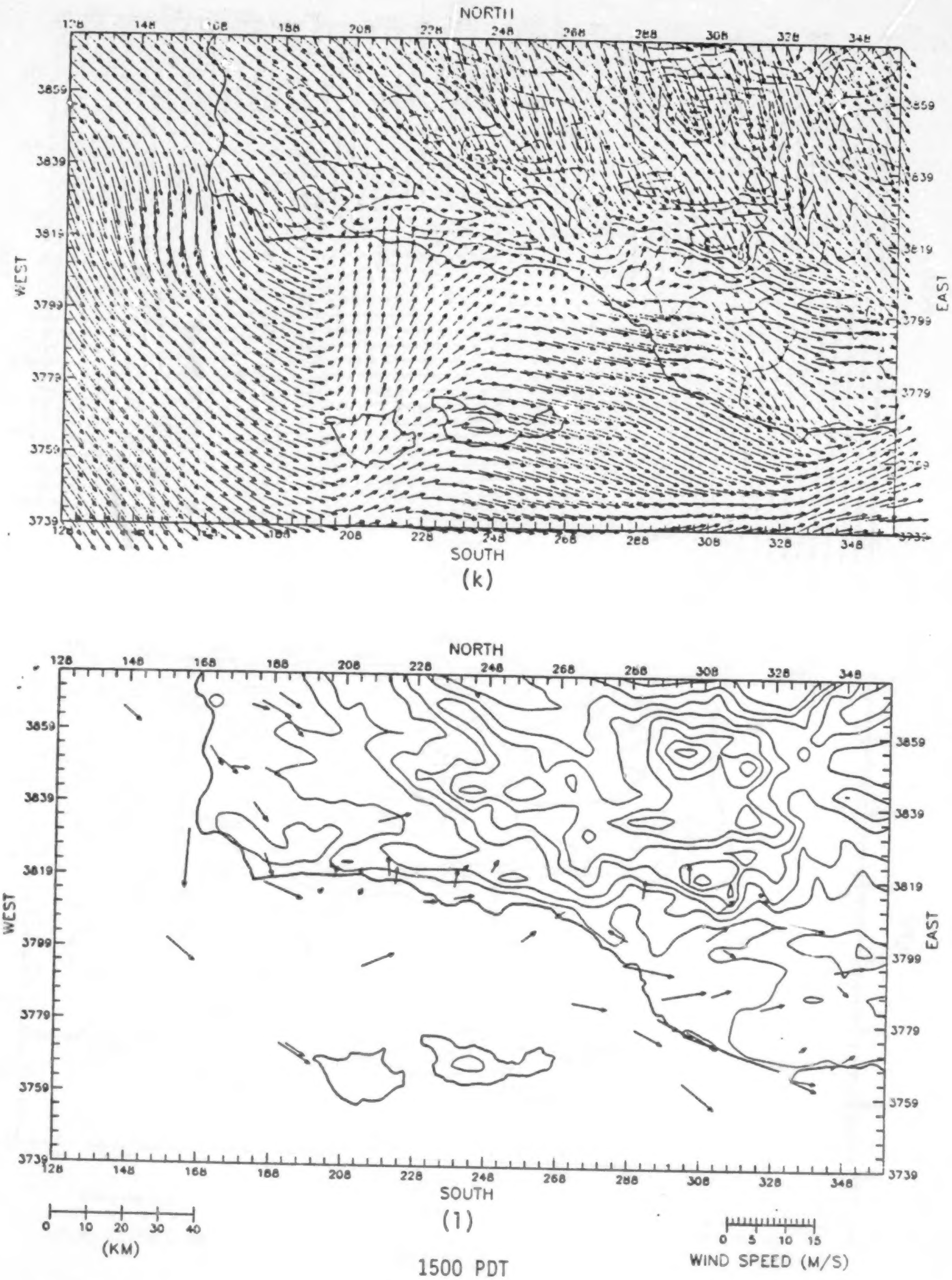
89024

87182


NORTH
SOUTH
WEST
EAST
128
148
168
188
208
228
248
268
288
308
328
348
3859
3839
3819
3799
3779
3759
3739
(i)
(j)
0 10 20 30 40
(KM)
0 5 10 15
WIND SPEED (M/S)

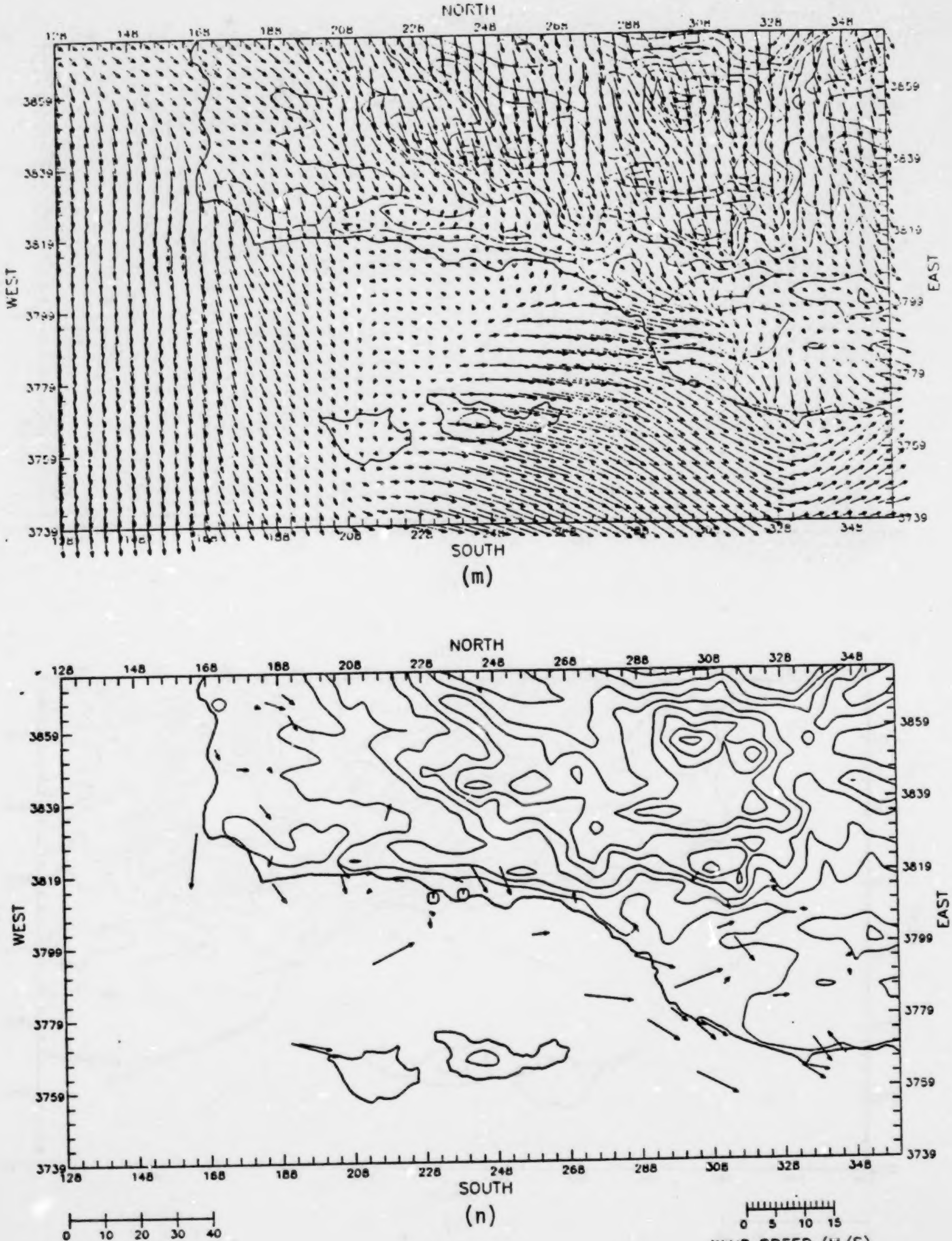
1200 PDT

FIGURE C-11. Continued.


NORTH
128
148
168
188
208
228
248
268
288
308
328
348
3859
3839
3819
3799
3779
3759
3739
WEST
EAST
SOUTH
(k)
(1)
0 10 20 30 40
(KM)
0 5 10 15
WIND SPEED (M/S)

1500 PDT

FIGURE C-11. Continued.


NORTH
SOUTH
WEST
EAST
128
148
168
188
208
228
248
268
288
308
328
348
3859
3839
3819
3799
3779
3759
3739
(m)
(n)
0 10 20 30 40
(KM)
0 5 10 15
WIND SPEED (M/S)

1800 PDT

FIGURE C-11. Continued.

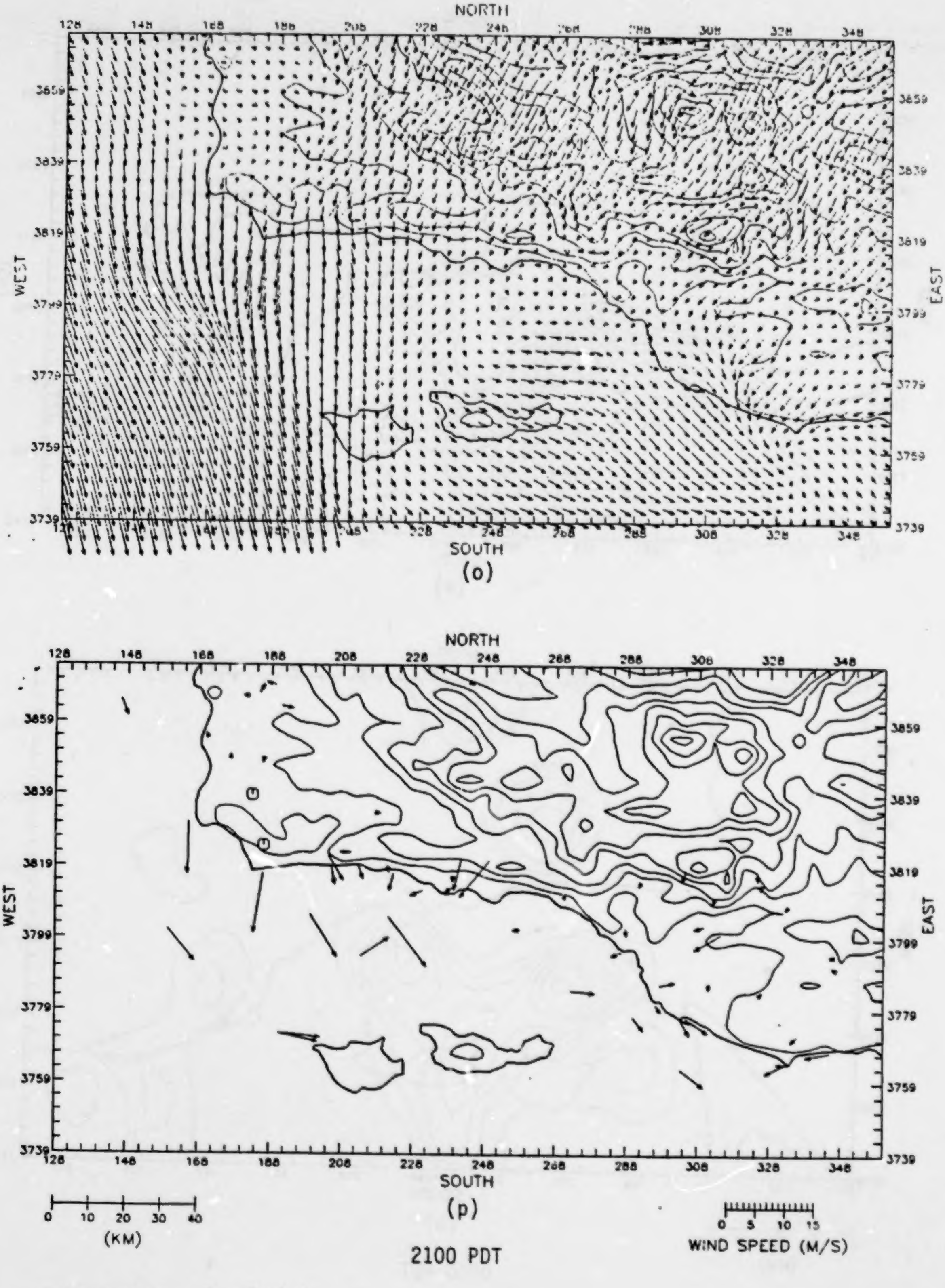
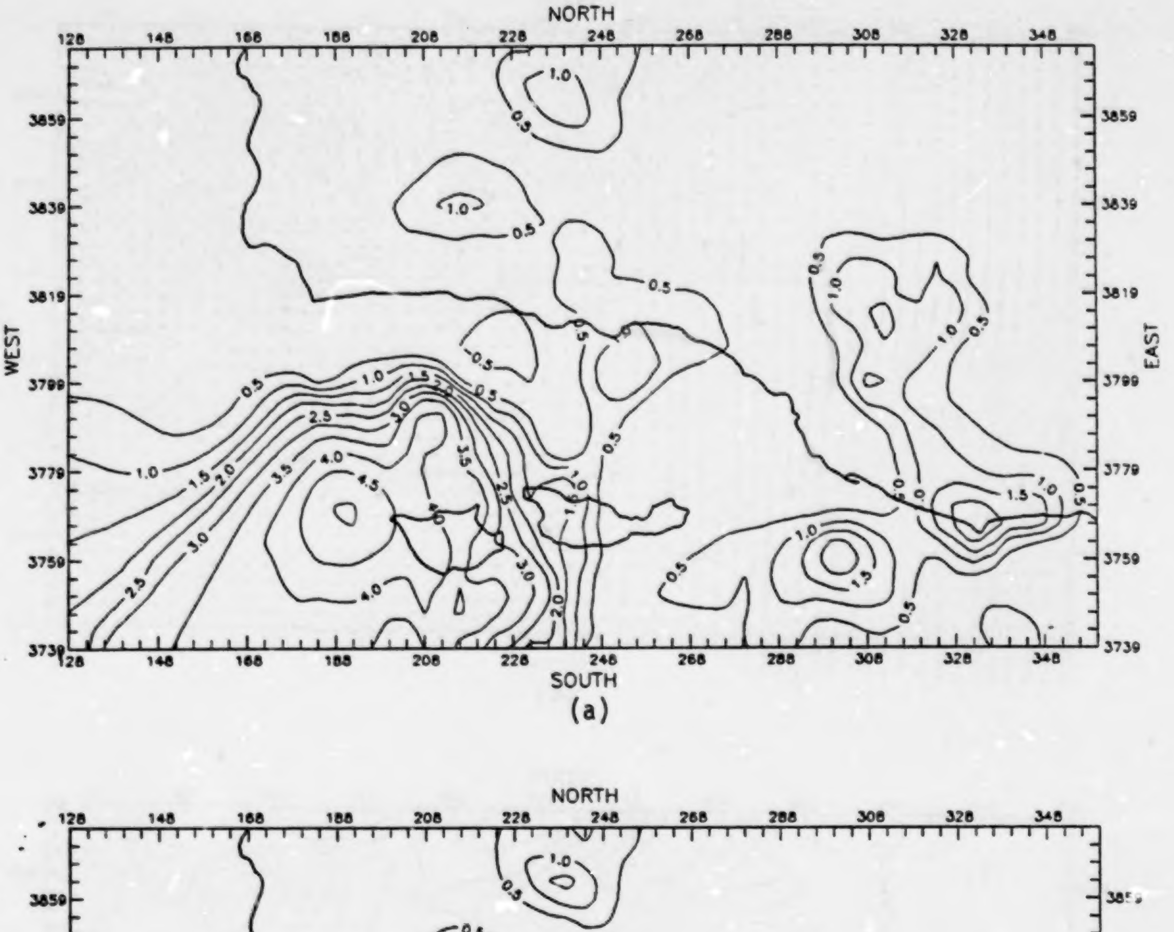

NORTH
SOUTH
WEST
EAST
128
148
168
188
208
228
248
268
288
308
328
348
3659
3639
3619
3599
3579
3559
3539
(o)
(p)
0 10 20 30 40
(KM)
0 5 10 15
WIND SPEED (M/S)
2100 PDT

FIGURE C-11. Concluded.



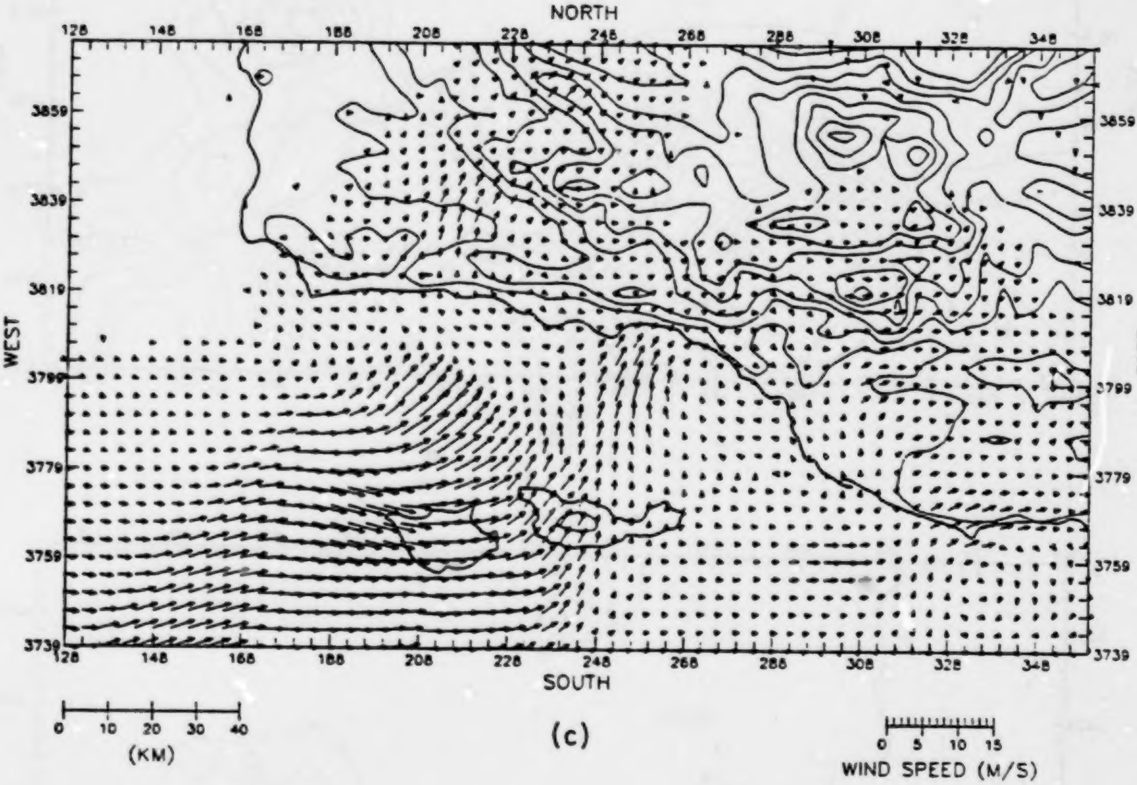
NORTH
SOUTH
WEST
EAST
128
148
168
188
208
228
248
268
288
308
328
348
3859
3839
3819
3799
3779
3759
3739
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
0
10
20
30
40
(KM)

(a)

(b)

0000 PDT

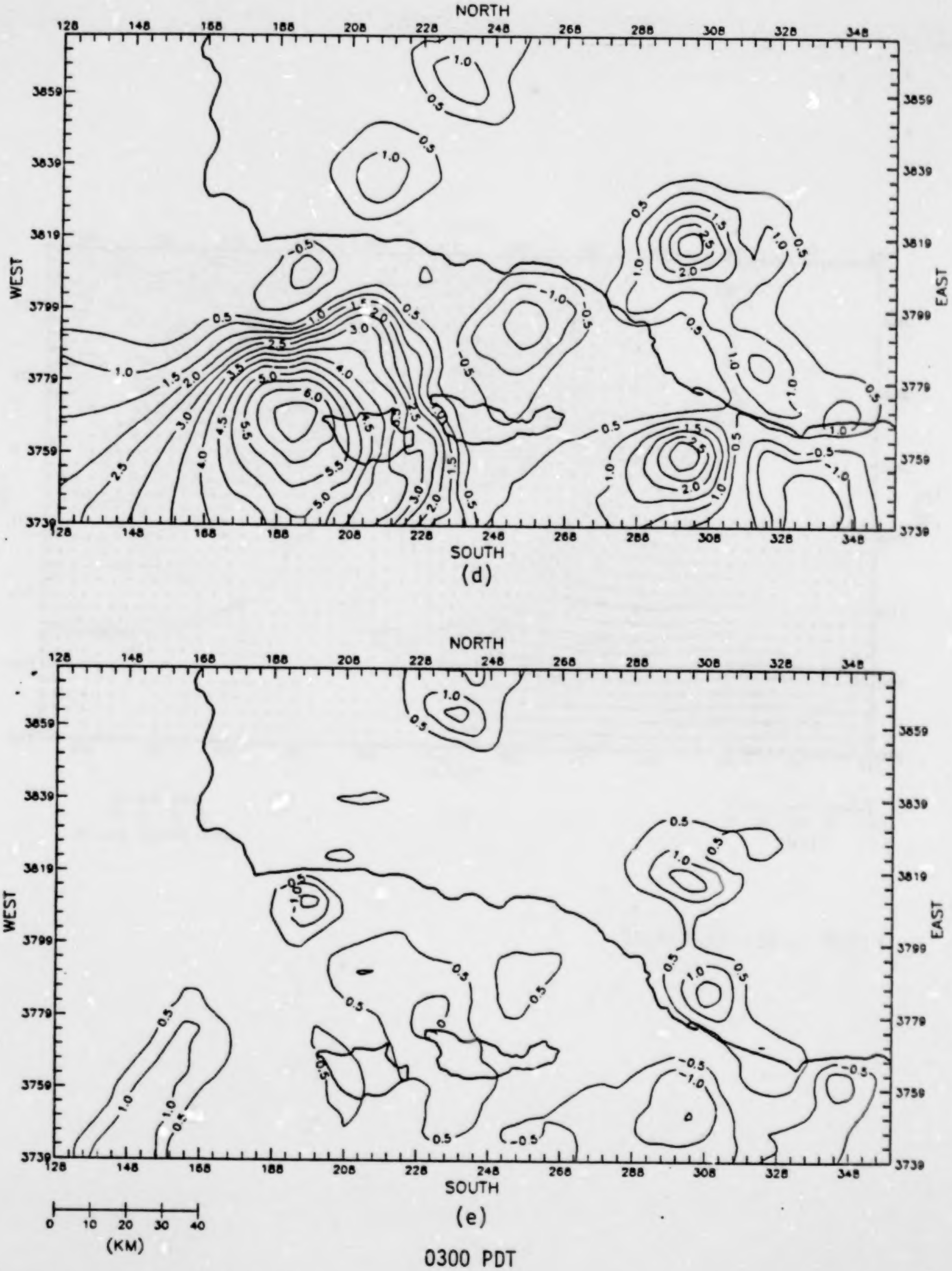
FIGURE C-12. Surface component (u and v) and vector difference fields illustrating the differences between the original diagnostic wind model run for 23 September 1985 and RTN1.



NORTH
128
148
168
188
208
228
248
268
288
308
328
348
WEST
3859
3839
3819
3799
3779
3759
3739
EAST
SOUTH
0
10
20
30
40
(KM)
(c)
0
5
10
15
WIND SPEED (M/S)

FIGURE C-12. Continued.

1 P 7


NORTH
SOUTH
WEST
EAST
128
148
168
188
208
228
248
268
288
308
328
348
3859
3839
3819
3799
3779
3759
3739
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
-0.5
-1.0
0
10
20
30
40
(KM)

(d)

(e)

0300 PDT

FIGURE C-12. Continued.

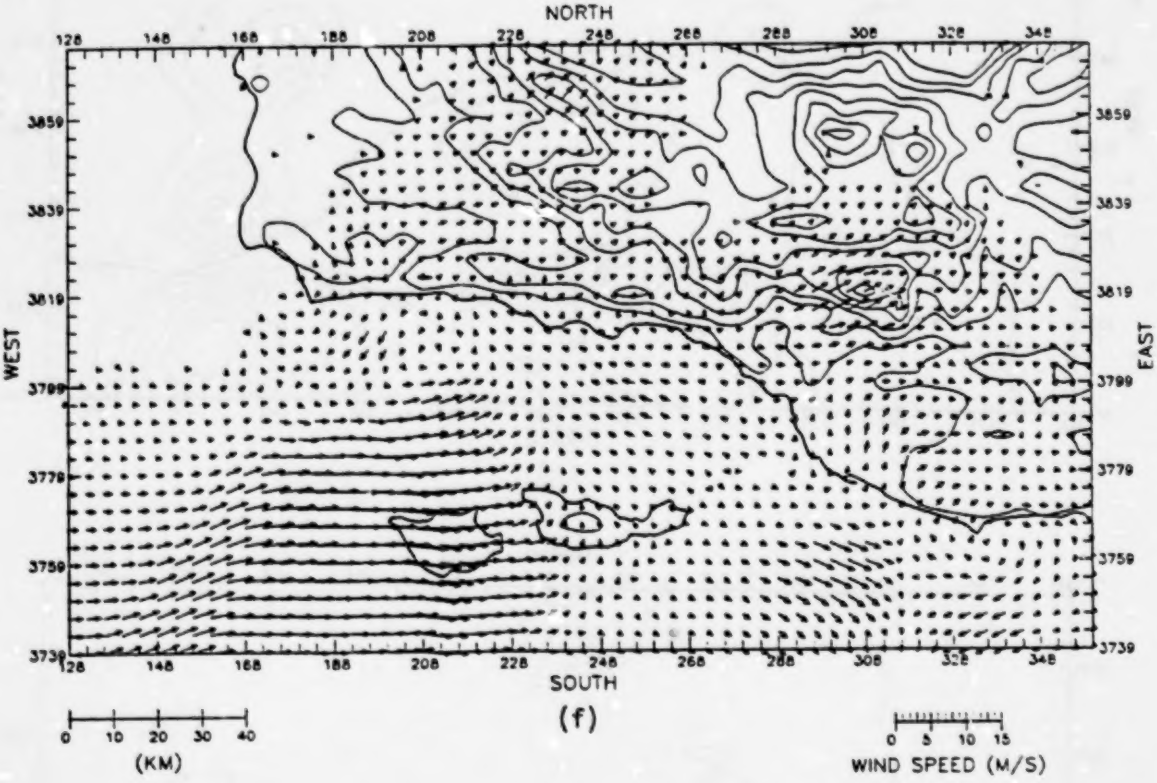
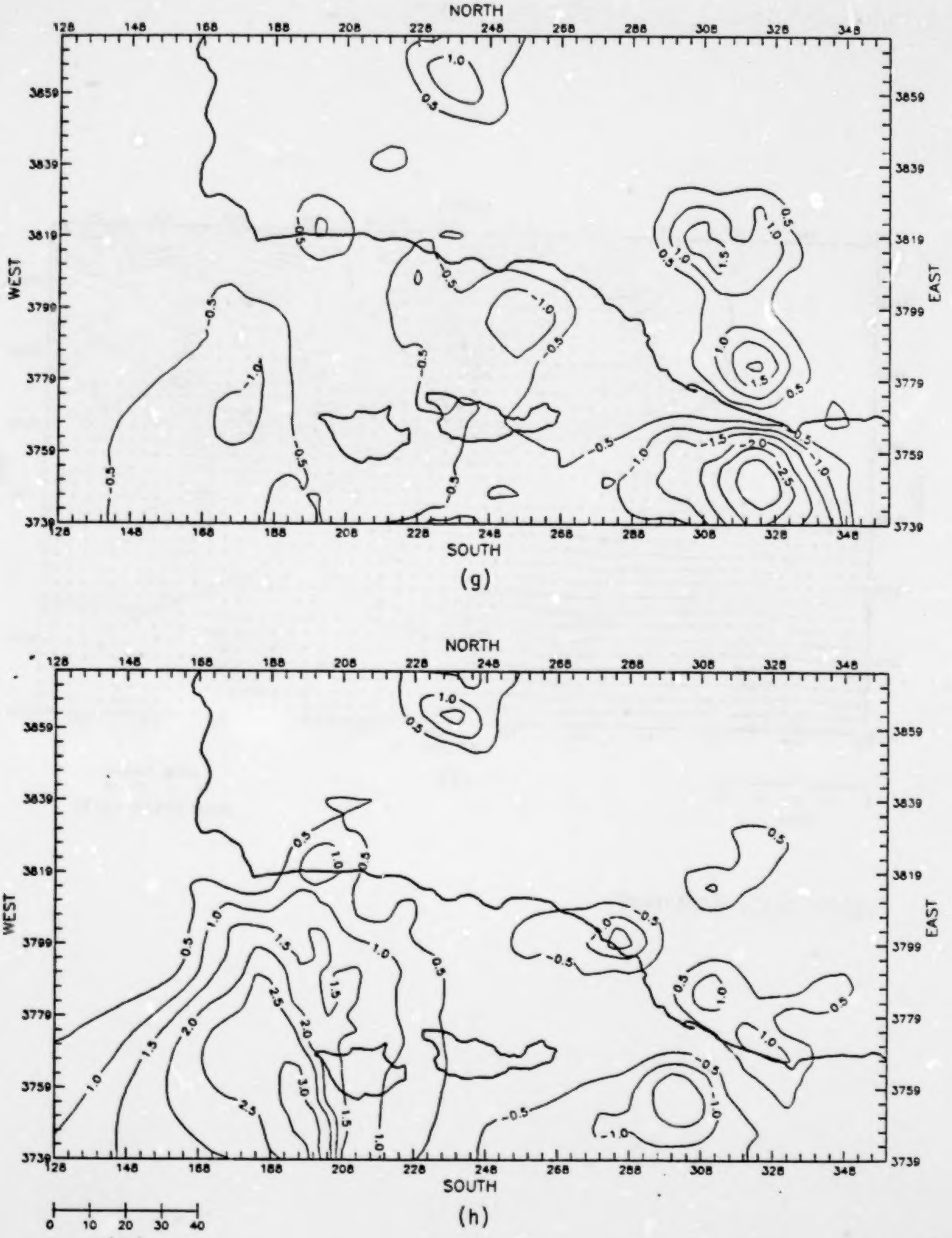

NORTH
128
148
168
188
208
228
248
268
288
308
328
348
3859
3839
3819
3799
3779
3759
3739
WEST
EAST
SOUTH
(f)
0 10 20 30 40
(KM)
0 5 10 15
WIND SPEED (M/S)

FIGURE C-12. Continued.


NORTH
SOUTH
WEST
EAST
128
148
168
188
208
228
248
268
288
308
328
348
3859
3839
3819
3799
3779
3759
3739
(g)
(h)
0
10
20
30
40
(KM)
0.5
1.0
1.5
2.0
2.5
3.0
-0.5
-1.0
-1.5
-2.0
-2.5

0600 PDT

FIGURE C-12. Continued.

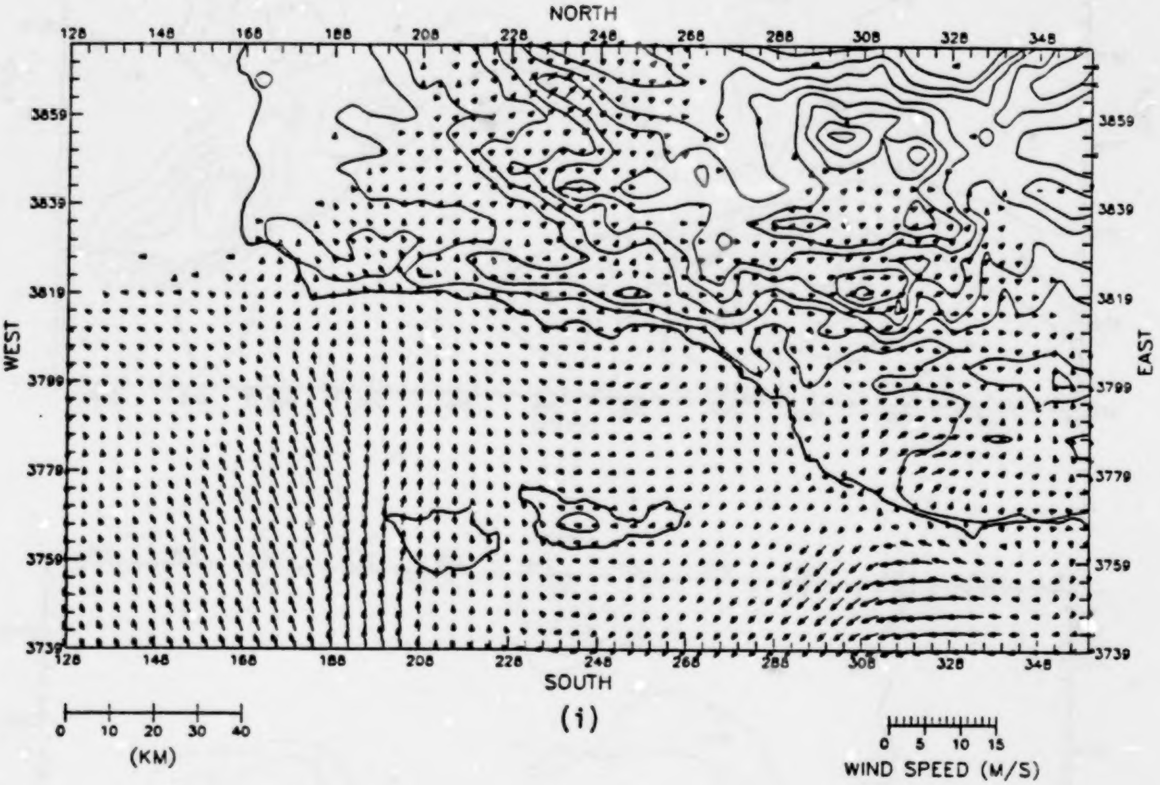
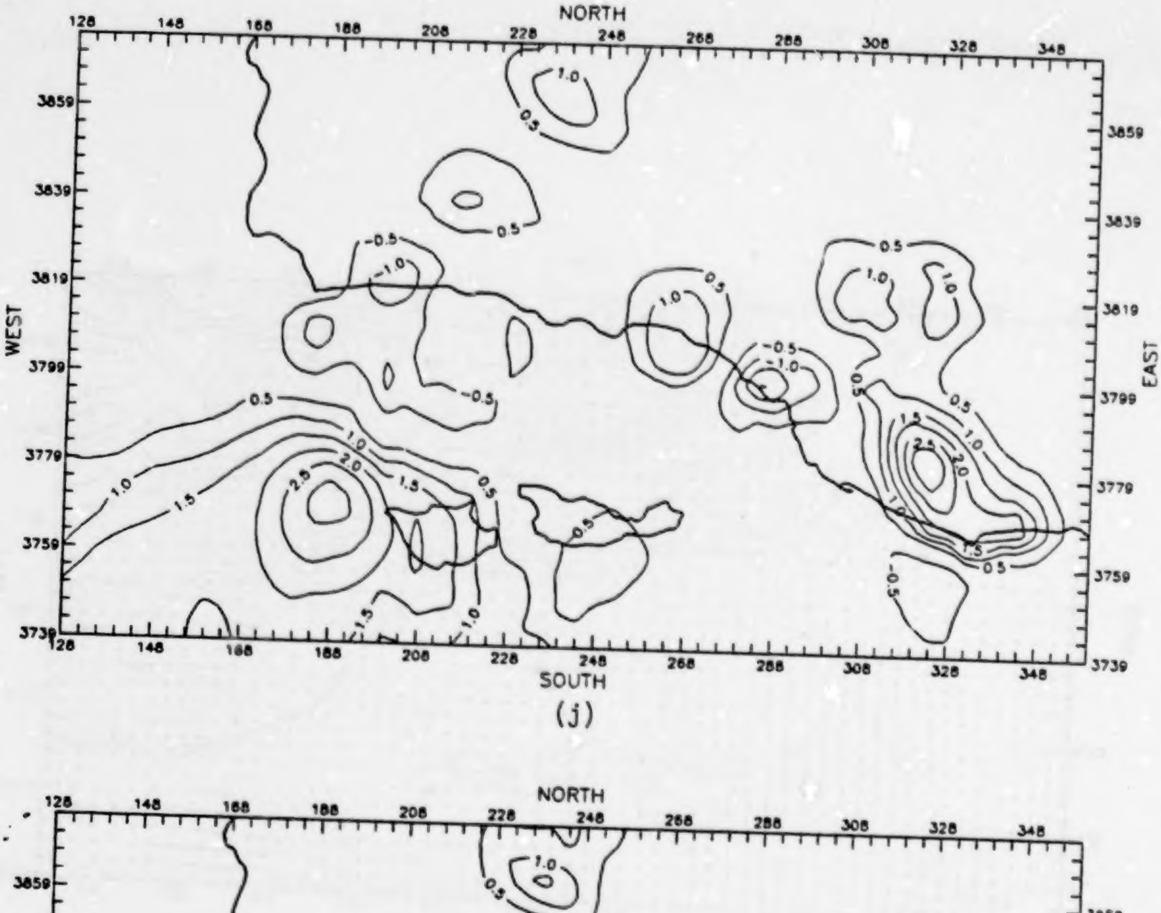

NORTH
SOUTH
WEST
EAST
128
148
168
188
208
228
248
268
288
308
328
348
3739
3759
3779
3799
3819
3839
3859
(i)
0
10
20
30
40
(KM)
0
5
10
15
WIND SPEED (M/S)

FIGURE C-12. Continued.


NORTH
SOUTH
WEST
EAST
128
148
168
188
208
228
248
268
288
308
328
348
3859
3839
3819
3799
3779
3759
3739
0.5
1.0
1.5
2.0
2.5
-0.5
-1.0
-1.5
-2.0
0
10
20
30
40
(KM)

(j)

(k)

0900 PDT

FIGURE C-12. Continued.

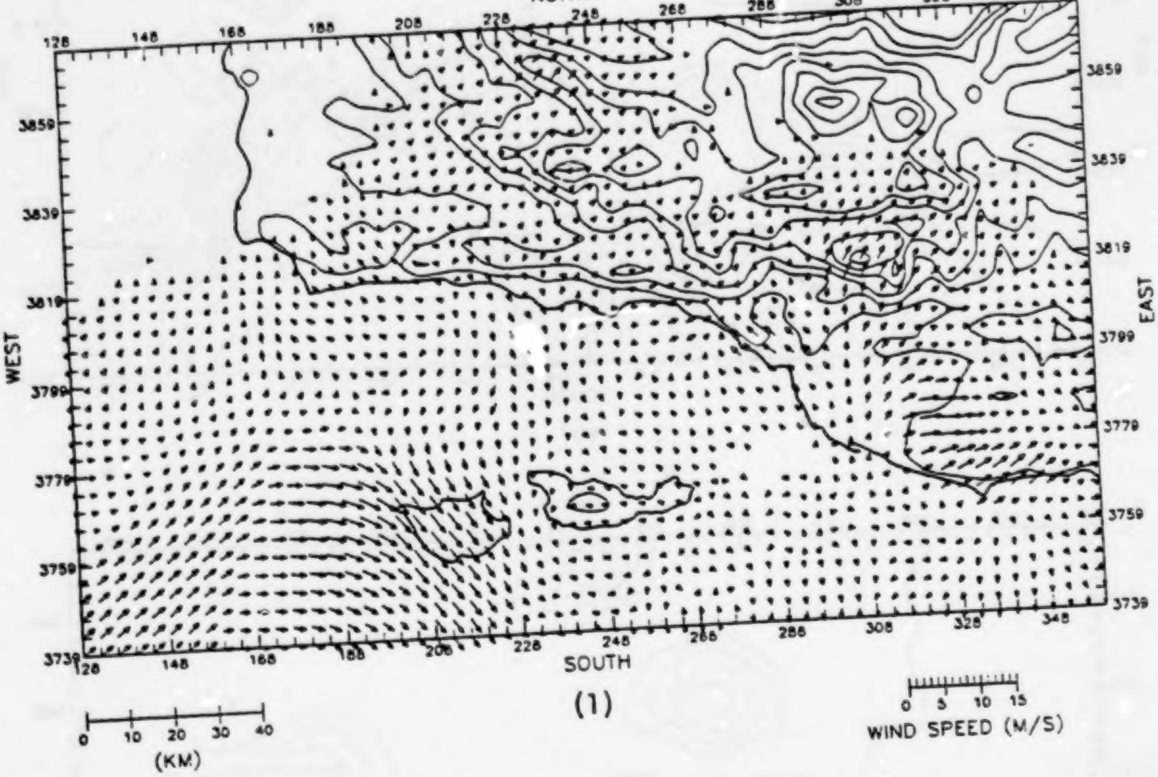
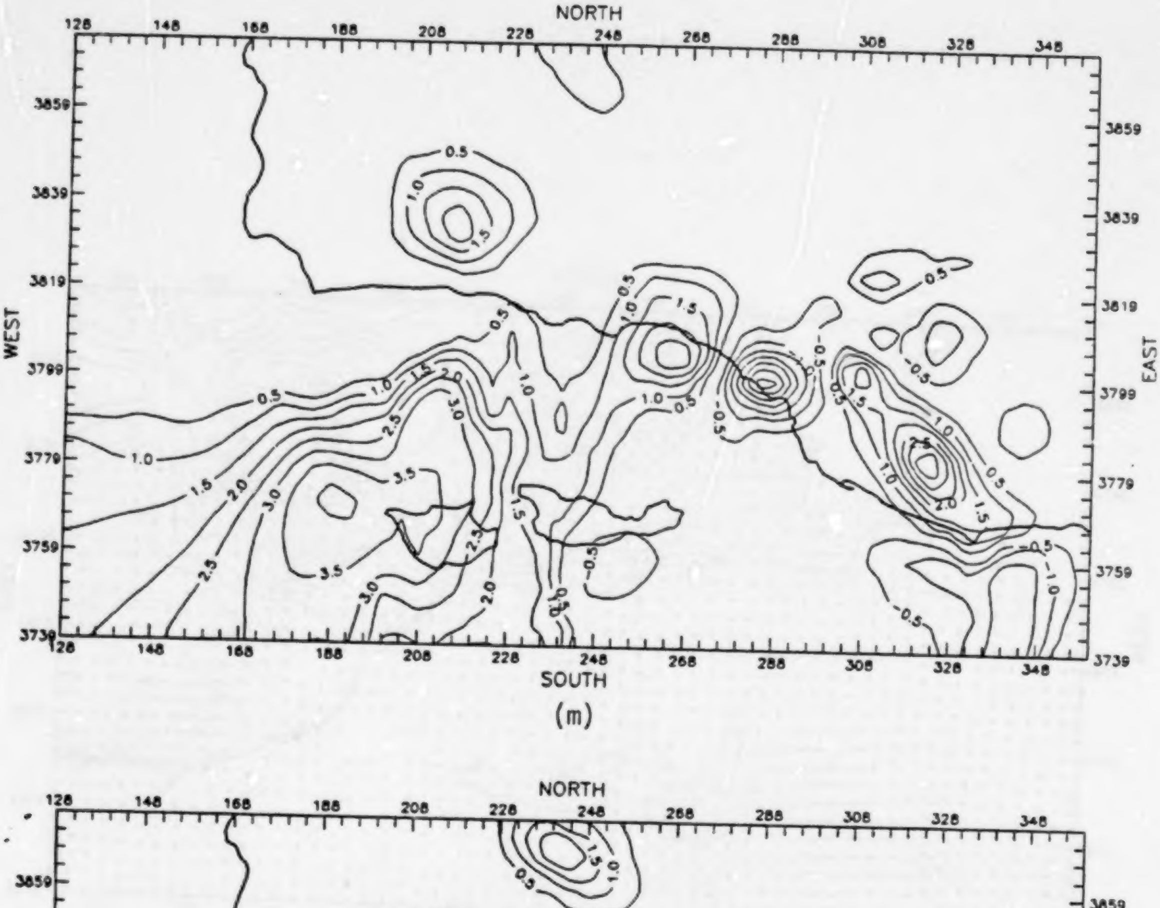

NORTH
SOUTH
WEST
EAST
128
148
168
188
208
228
248
268
288
308
328
348
3739
3759
3779
3799
3819
3839
3859
(1)
0
10
20
30
40
(KM)
0
5
10
15
WIND SPEED (M/S)

FIGURE C-12. Continued.


NORTH
SOUTH
WEST
EAST
128
148
168
188
208
228
248
268
288
308
328
348
3859
3839
3819
3799
3779
3759
3739
0.5
1.0
1.5
2.0
2.5
3.0
3.5
0
10
20
30
40
(KM)

(m)

(n)

1200 PDT

FIGURE C-12. Continued.

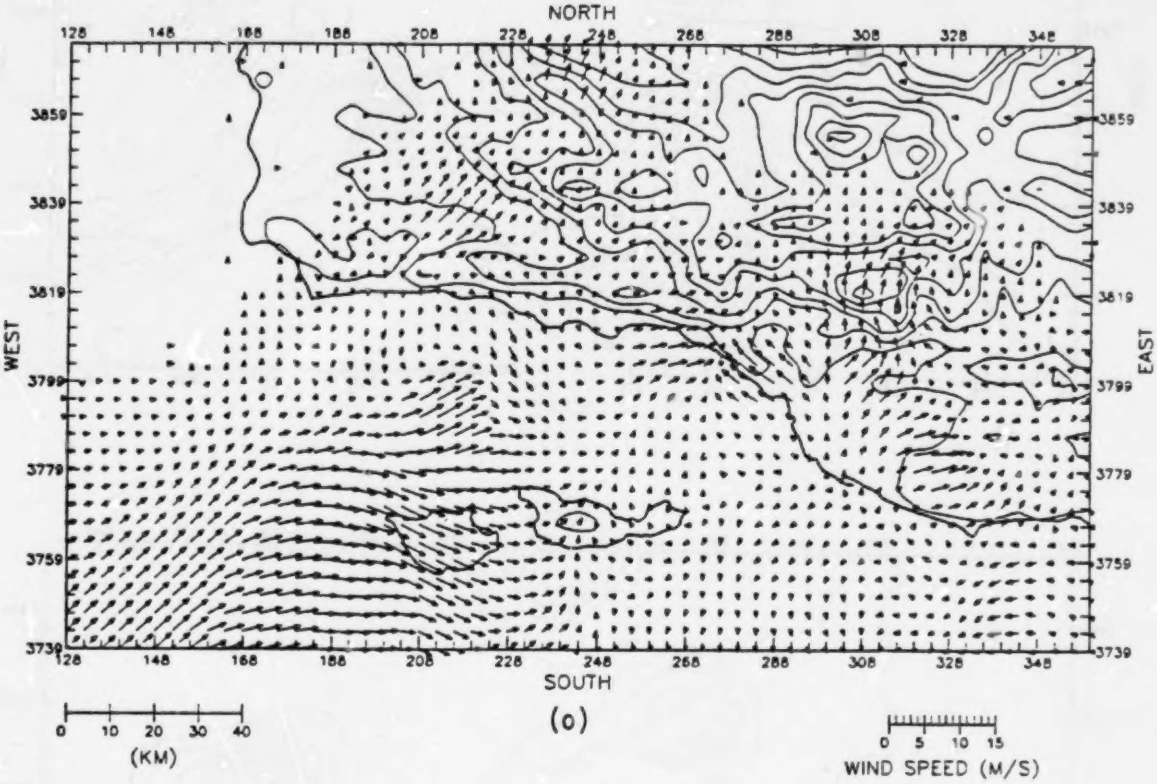
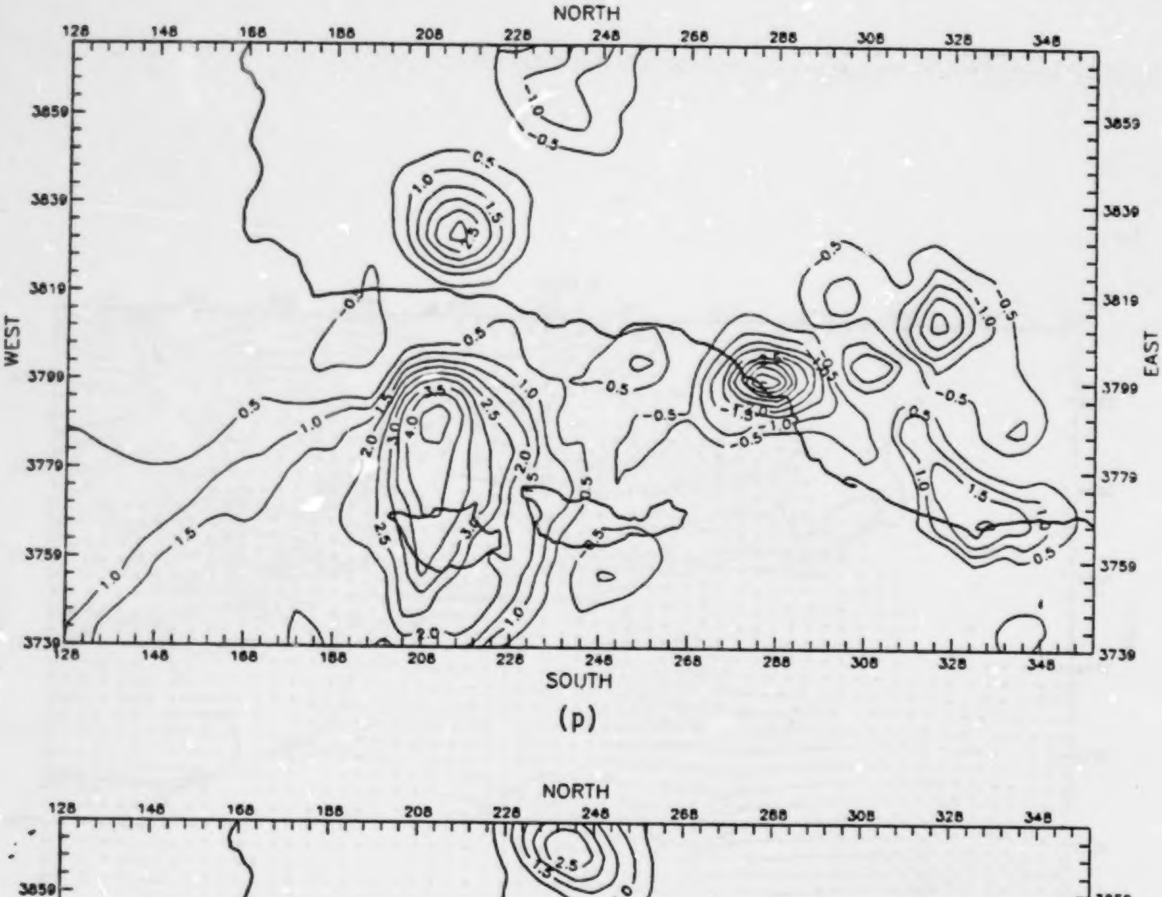

NORTH
SOUTH
WEST
EAST
128
148
168
188
208
228
248
268
288
308
328
348
3859
3839
3819
3799
3779
3759
3739
(o)
0 10 20 30 40
(KM)
0 5 10 15
WIND SPEED (M/S)

FIGURE C-12. Continued.


NORTH
SOUTH
WEST
EAST
128
148
168
188
208
228
248
268
288
308
328
348
3859
3839
3819
3799
3779
3759
3739
0
10
20
30
40
(KM)

(p)

(q)

1500 PDT

FIGURE C-12. Continued.

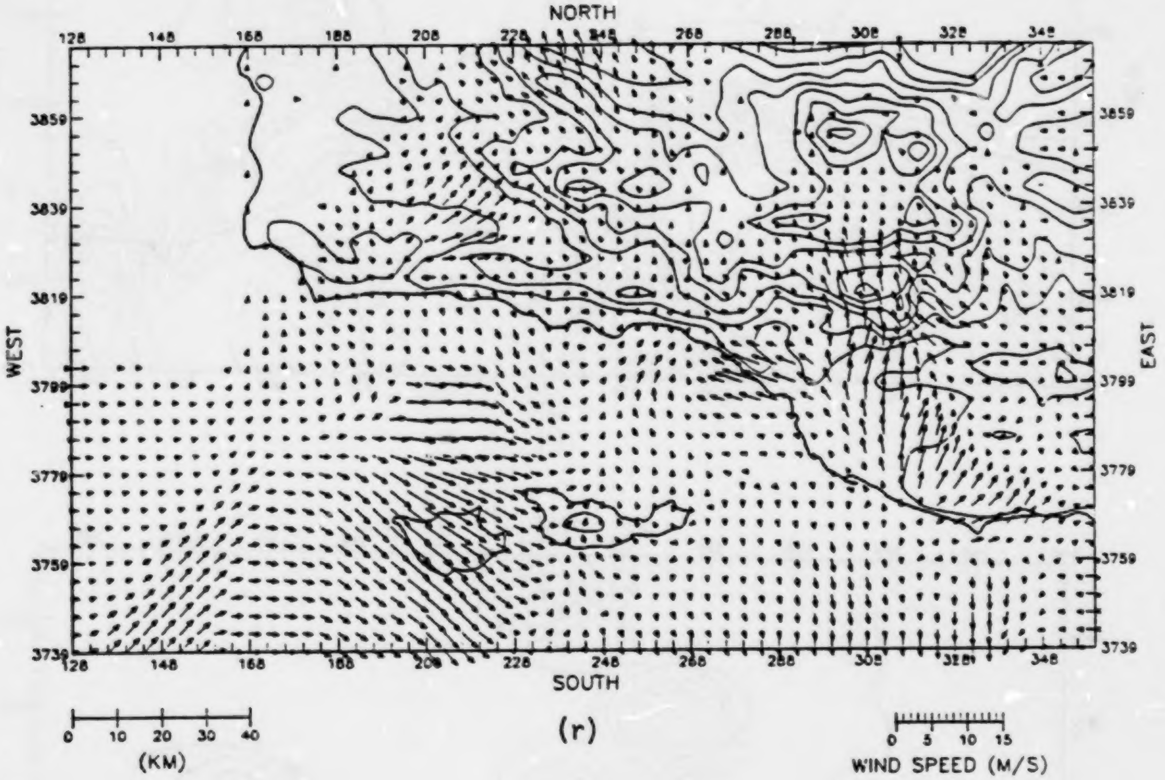
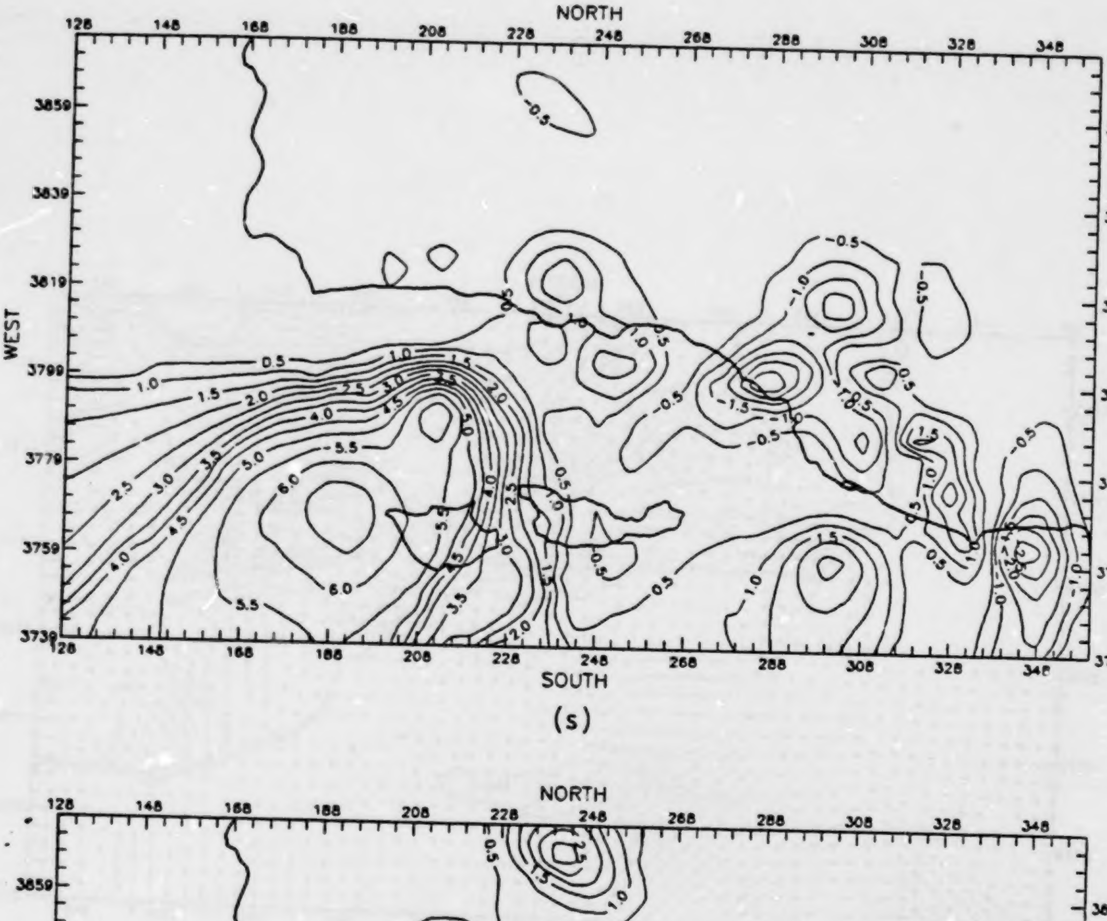

NORTH
SOUTH
WEST
EAST
128
148
168
188
208
228
248
268
288
308
328
348
3859
3839
3819
3799
3779
3759
3739
0
10
20
30
40
(KM)
(r)
0
5
10
15
WIND SPEED (M/S)

FIGURE C-12. Continued.


NORTH
SOUTH
WEST
EAST
128
148
168
188
208
228
248
268
288
308
328
348
3859
3839
3819
3799
3779
3759
3739
0
10
20
30
40
(KM)

(s)

(t)

1800 PDT

FIGURE C-12. Continued.

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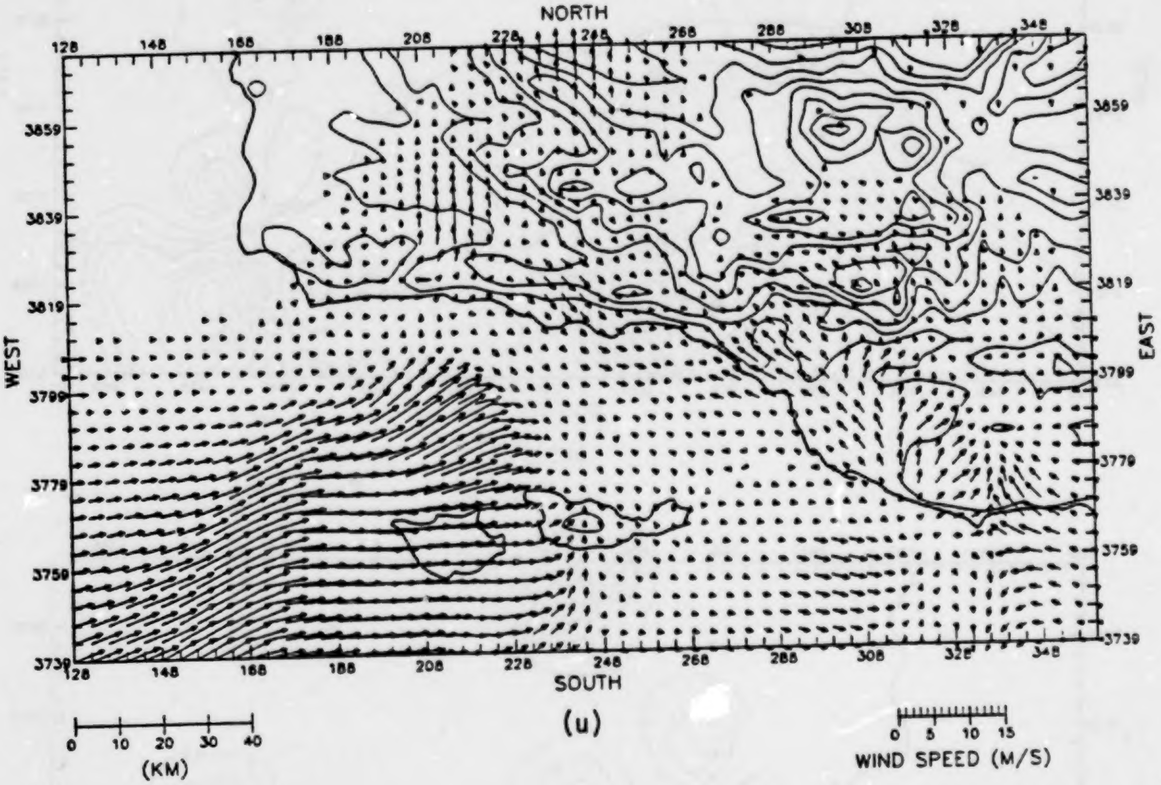
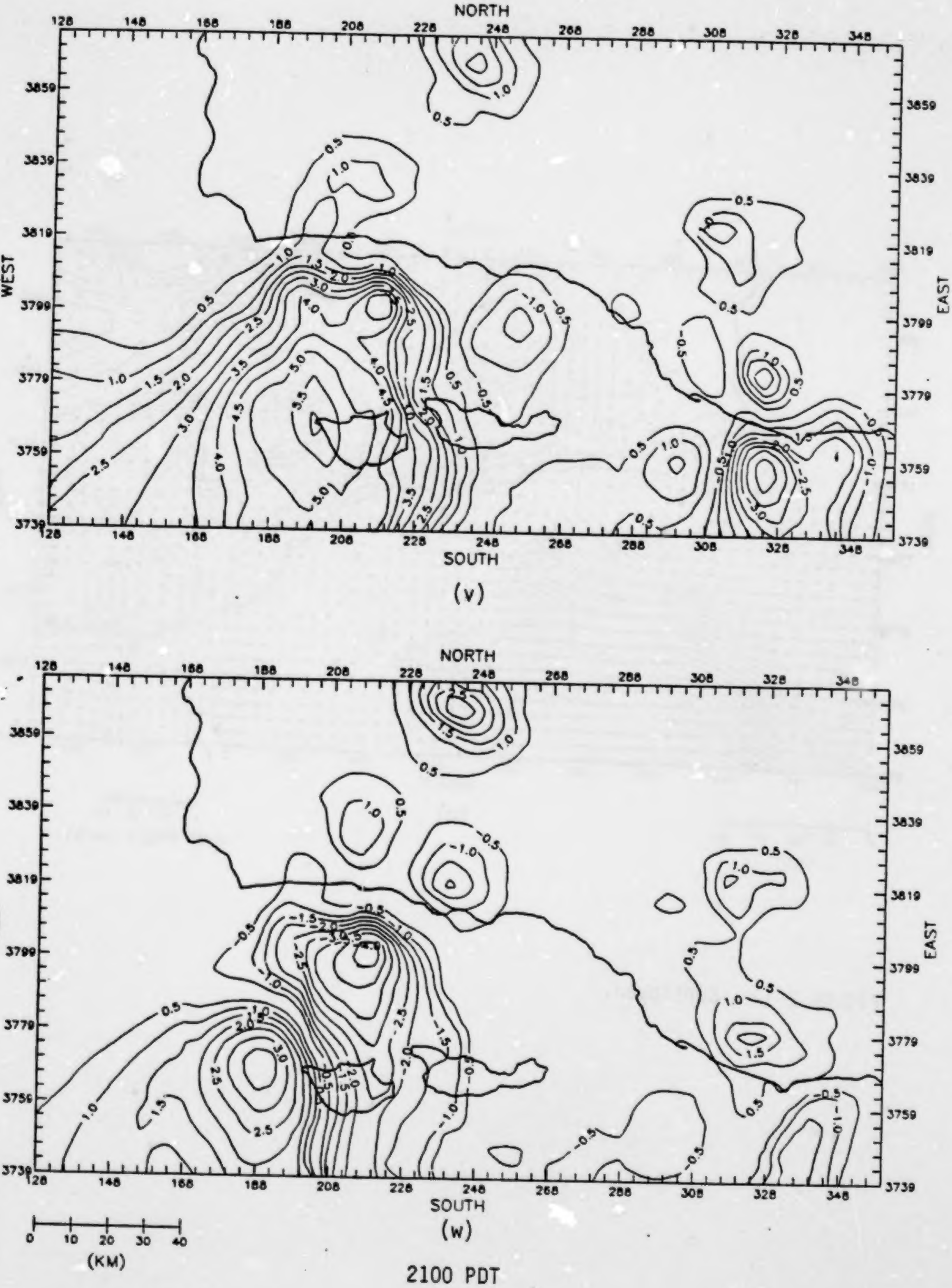

NORTH
SOUTH
WEST
EAST
128
148
168
188
208
228
248
268
288
308
328
348
3859
3839
3819
3799
3779
3759
3739
(u)
0
10
20
30
40
(KM)
0
5
10
15
WIND SPEED (M/S)

FIGURE C-12. Continued.


NORTH
SOUTH
WEST
EAST
128
148
168
188
208
228
248
268
288
308
328
348
3859
3839
3819
3799
3779
3759
3739
(v)
(w)
0
10
20
30
40
(KM)

2100 PDT

FIGURE C-12. Continued.

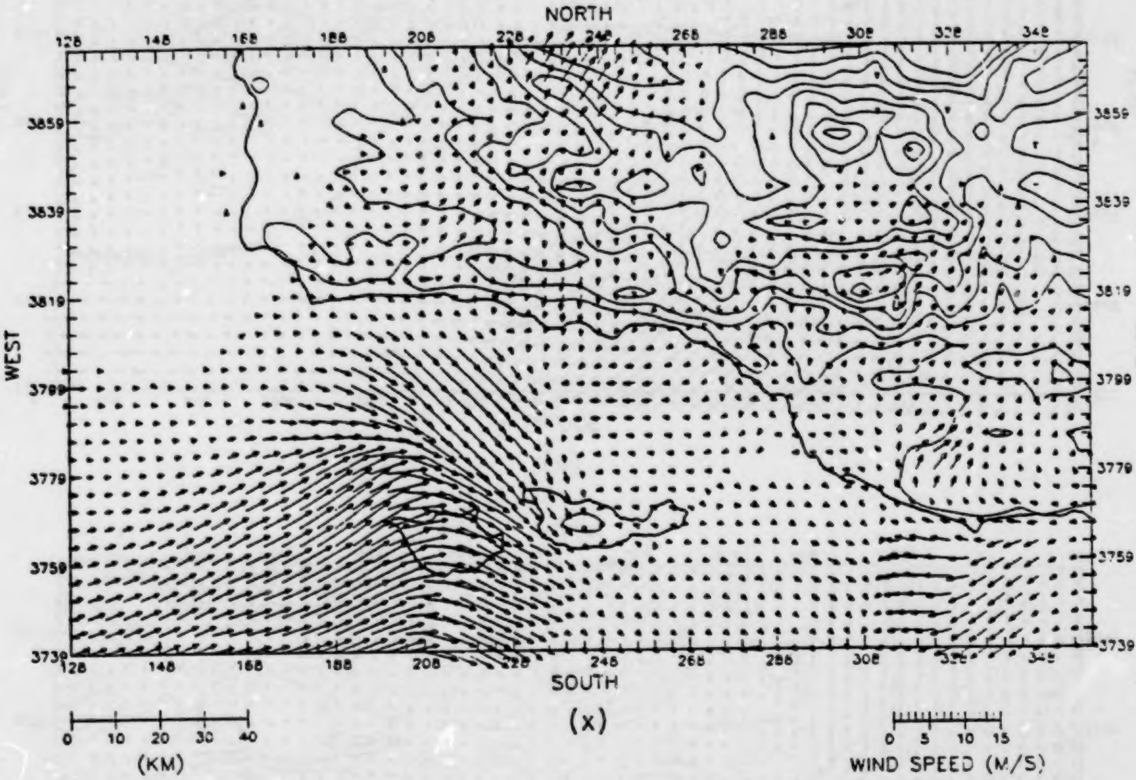

NORTH
SOUTH
WEST
EAST
128
148
168
188
208
228
248
268
288
308
328
348
3859
3839
3819
3799
3779
3759
3739
(x)
0
10
20
30
40
(KM)
0
5
10
15
WIND SPEED (M/S)

FIGURE C-12. Concluded.

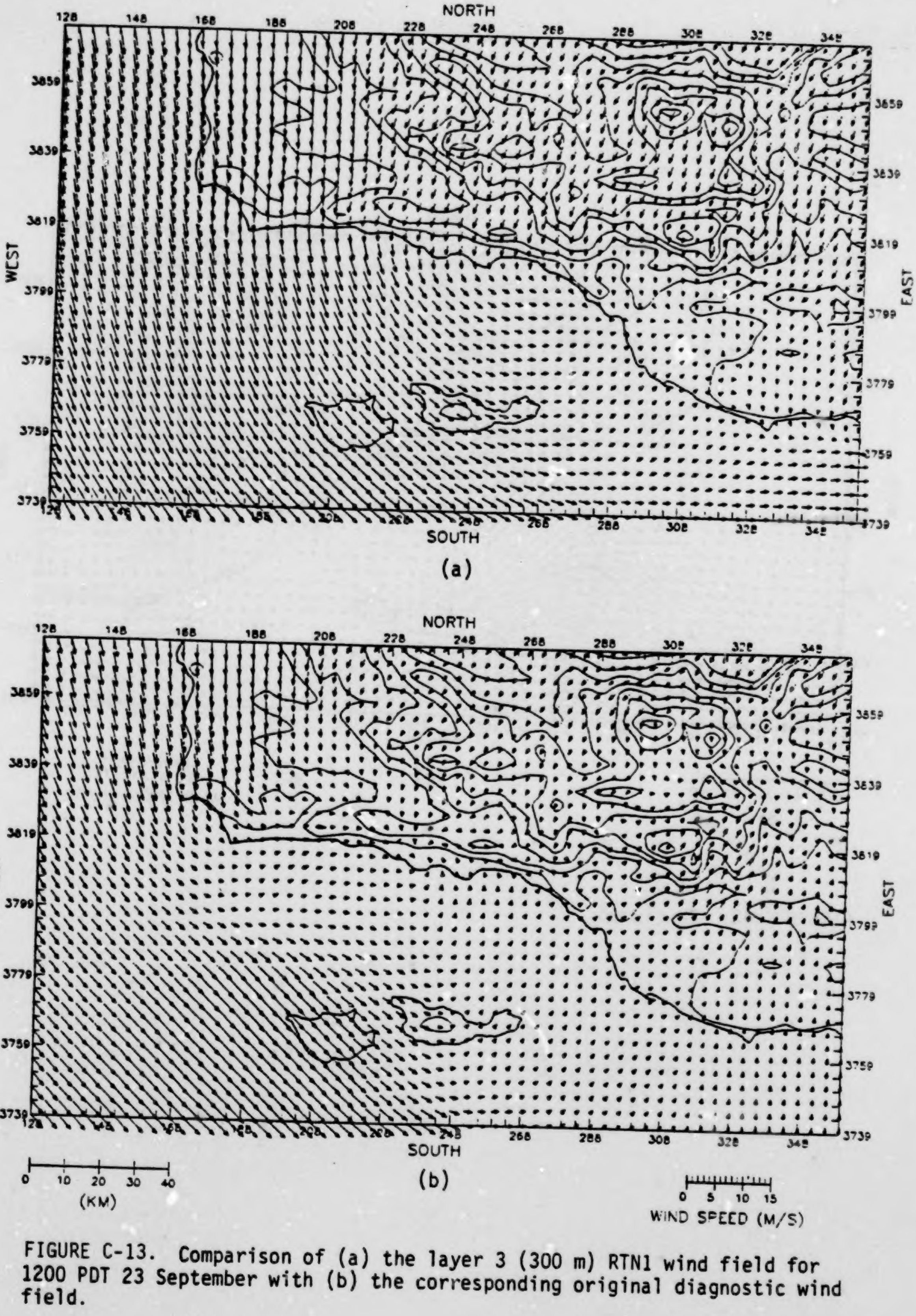

NORTH
128 148 168 188 208 228 248 268 288 308 328 348
WEST
3859 3839 3819 3799 3779 3759 3739
EAST
SOUTH
(a)
(b)
0 10 20 30 40
(KM)
0 5 10 15
WIND SPEED (M/S)

FIGURE C-13. Comparison of (a) the layer 3 (300 m) RTN1 wind field for 1200 PDT 23 September with (b) the corresponding original diagnostic wind field.

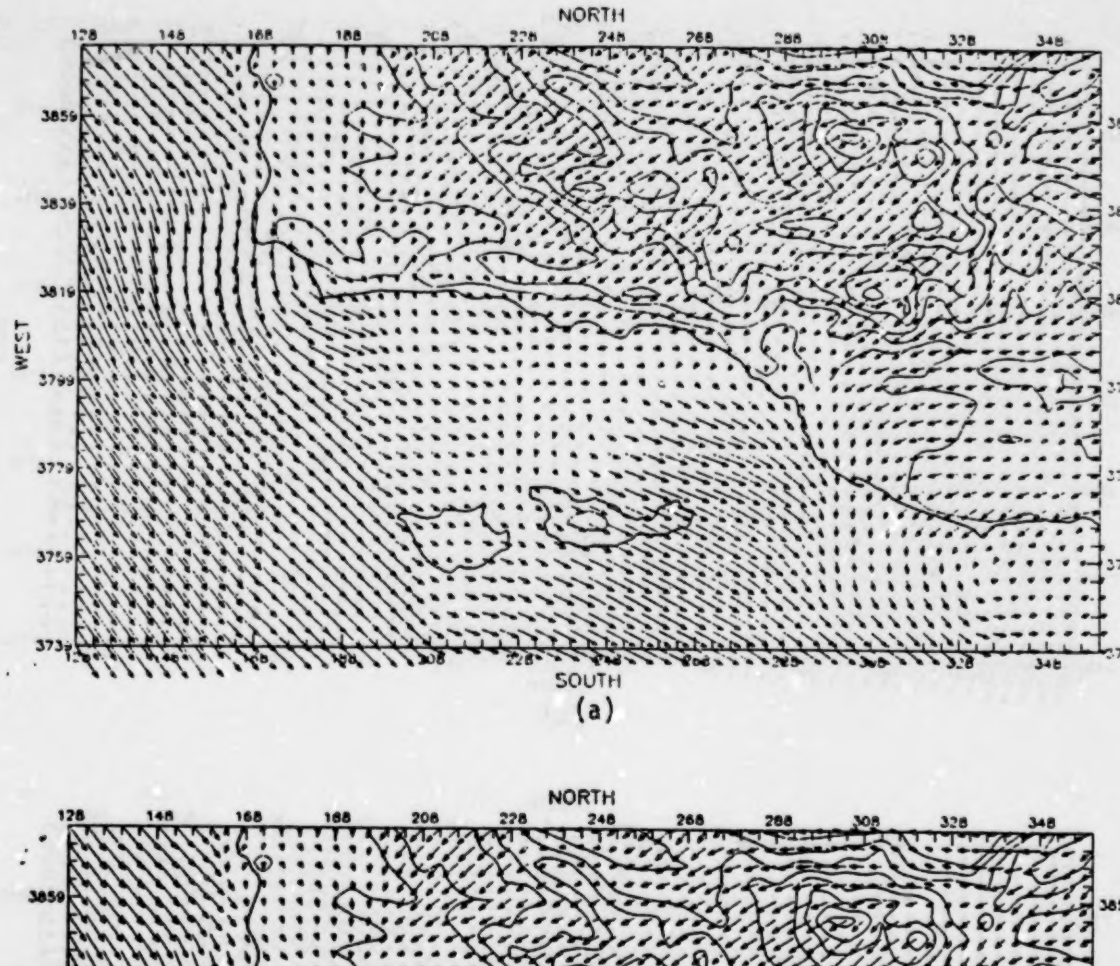
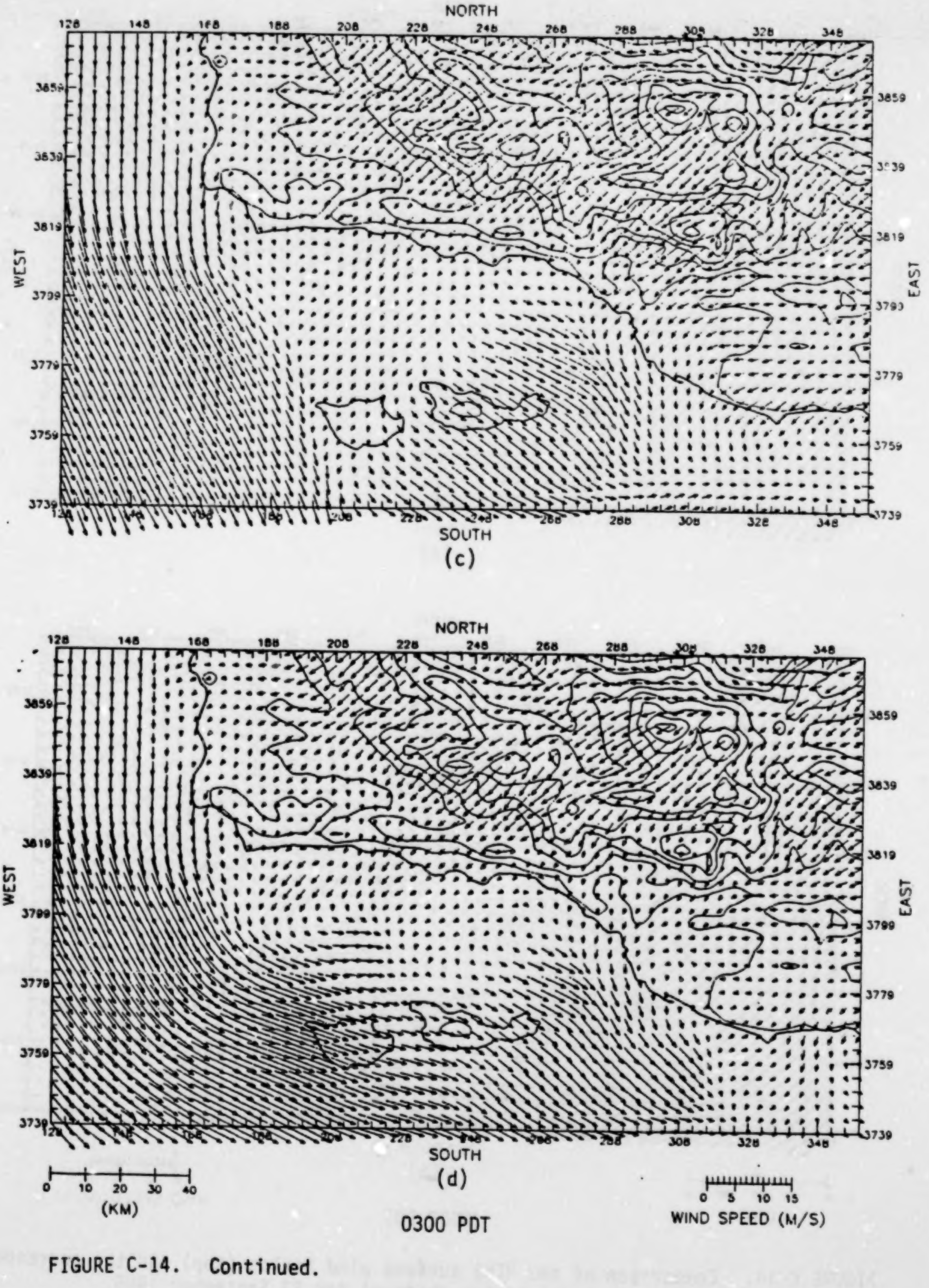
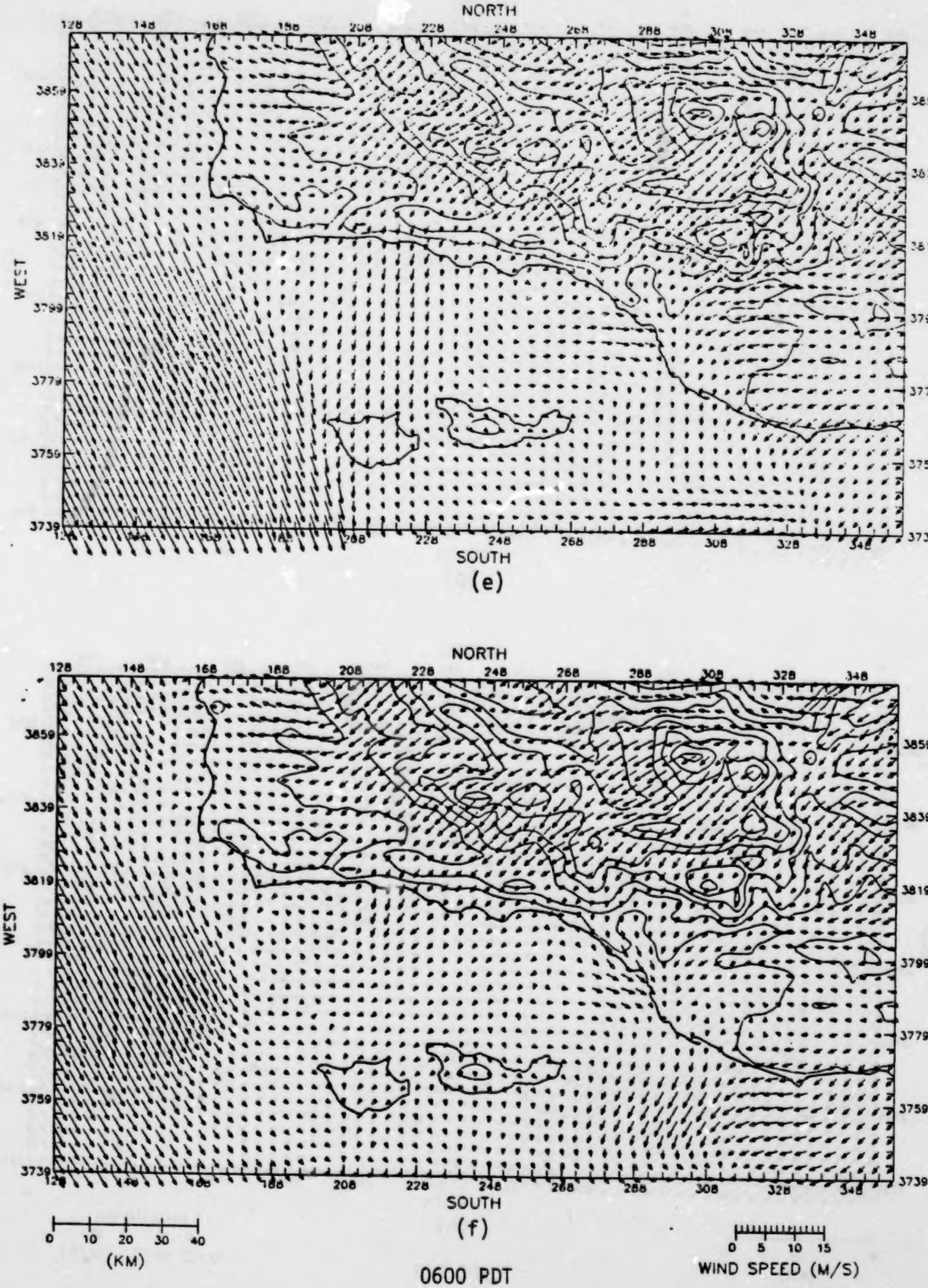

NORTH
128 148 168 188 208 228 248 268 288 308 328 348
3859 3839 3819 3799 3779 3759 3739
WEST
EAST
SOUTH
(a)
NORTH
SOUTH
(b)
0 10 20 30 40
(KM)
0000 PDT
0 5 10 15
WIND SPEED (M/S)

FIGURE C-14. Comparison of the RTN2 surface wind fields (top) and the corresponding original diagnostic wind model fields (bottom) for 23 September 1985.


NORTH
128
148
168
188
208
228
248
268
288
308
328
348
3859
3839
3819
3799
3779
3759
3739
WEST
EAST
SOUTH
(c)
NORTH
(d)
0
10
20
30
40
(KM)
0
5
10
15
WIND SPEED (M/S)

0300 PDT

FIGURE C-14. Continued.


NORTH
128
148
168
188
208
228
248
268
288
308
328
348
3859
3839
3819
3799
3779
3759
3739
WEST
EAST
SOUTH
(e)
(f)
0
10
20
30
40
(KM)
0
5
10
15
WIND SPEED (M/S)

0600 PDT

FIGURE C-14. Continued.

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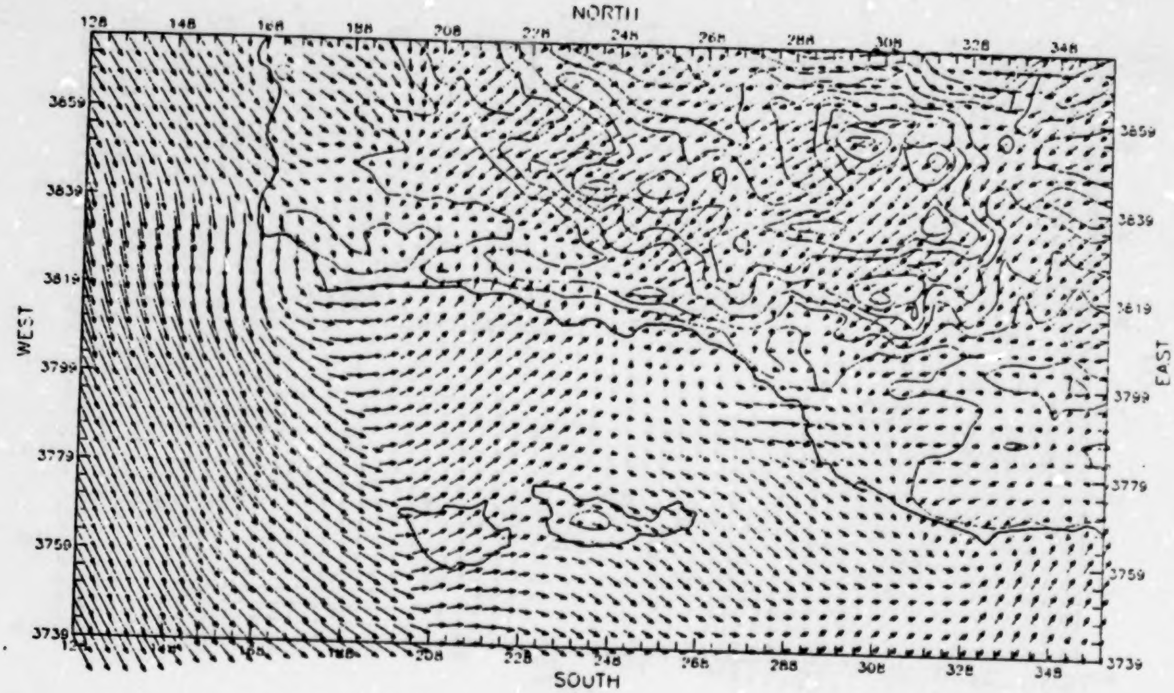
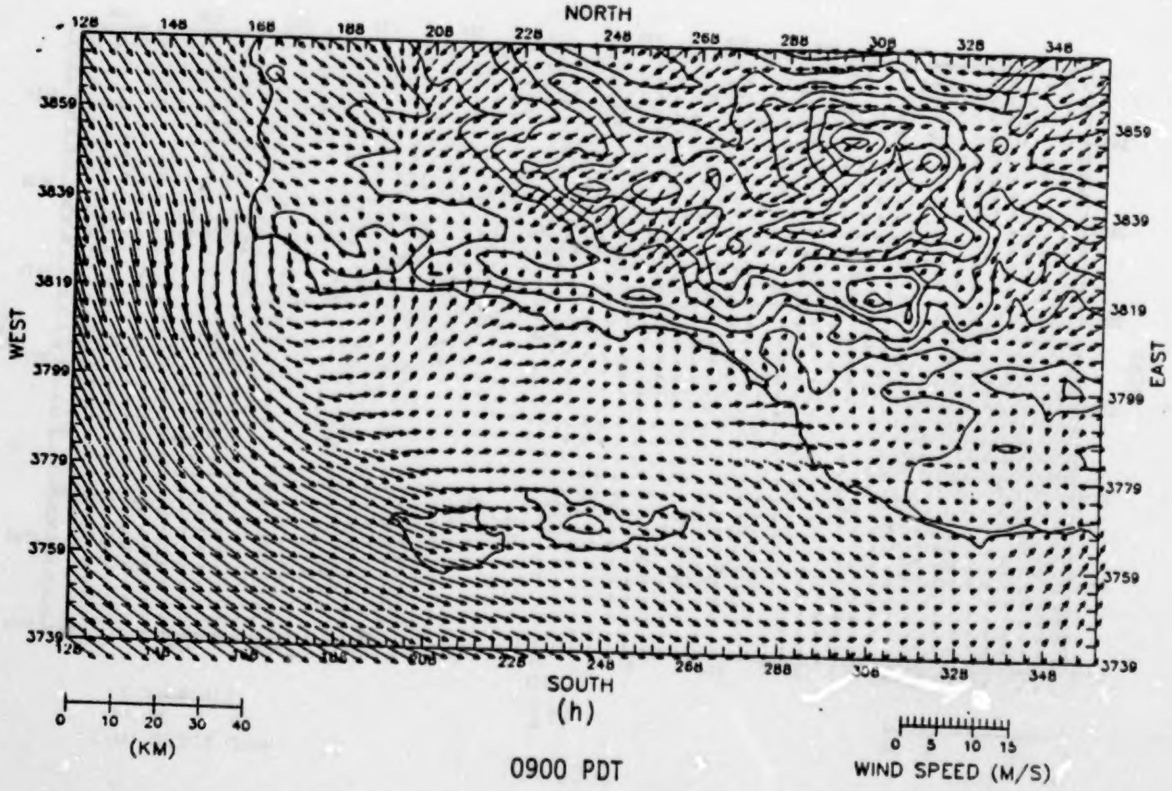

NORTH
SOUTH
WEST
EAST
128
148
168
188
208
228
248
268
288
308
328
348
3659
3839
3819
3799
3779
3759
3739

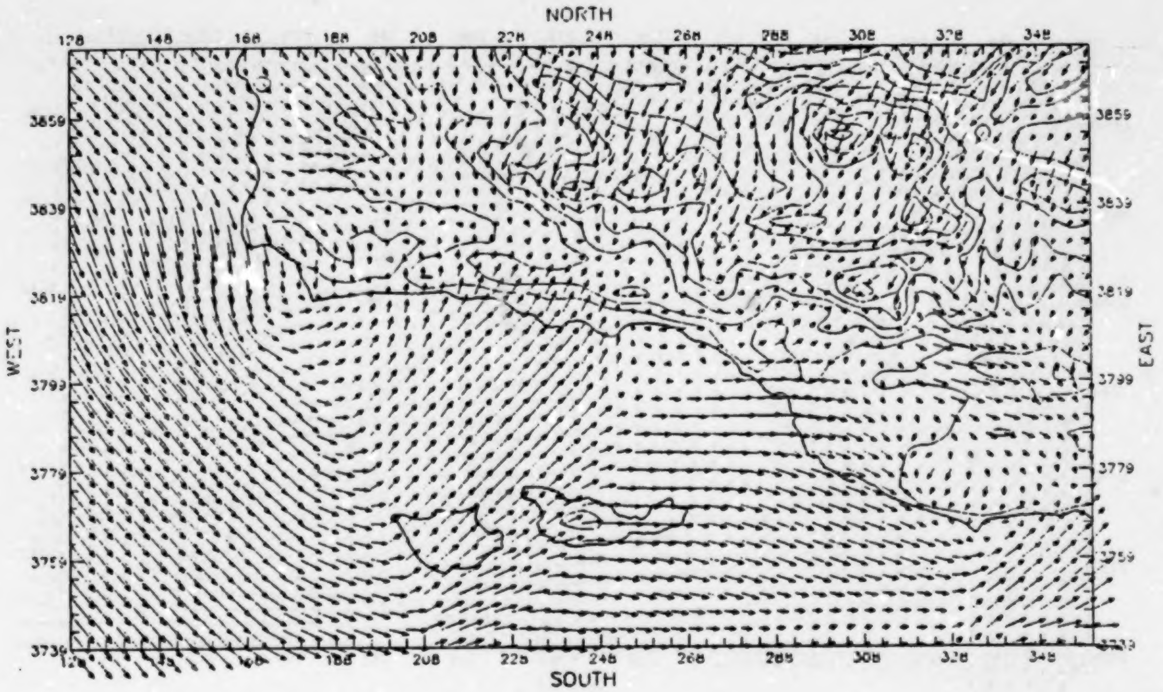
(g)


NORTH
SOUTH
WEST
EAST
128
148
168
188
208
228
248
268
288
308
328
348
3859
3839
3819
3799
3779
3759
3739
0
10
20
30
40
(KM)
0
5
10
15
WIND SPEED (M/S)

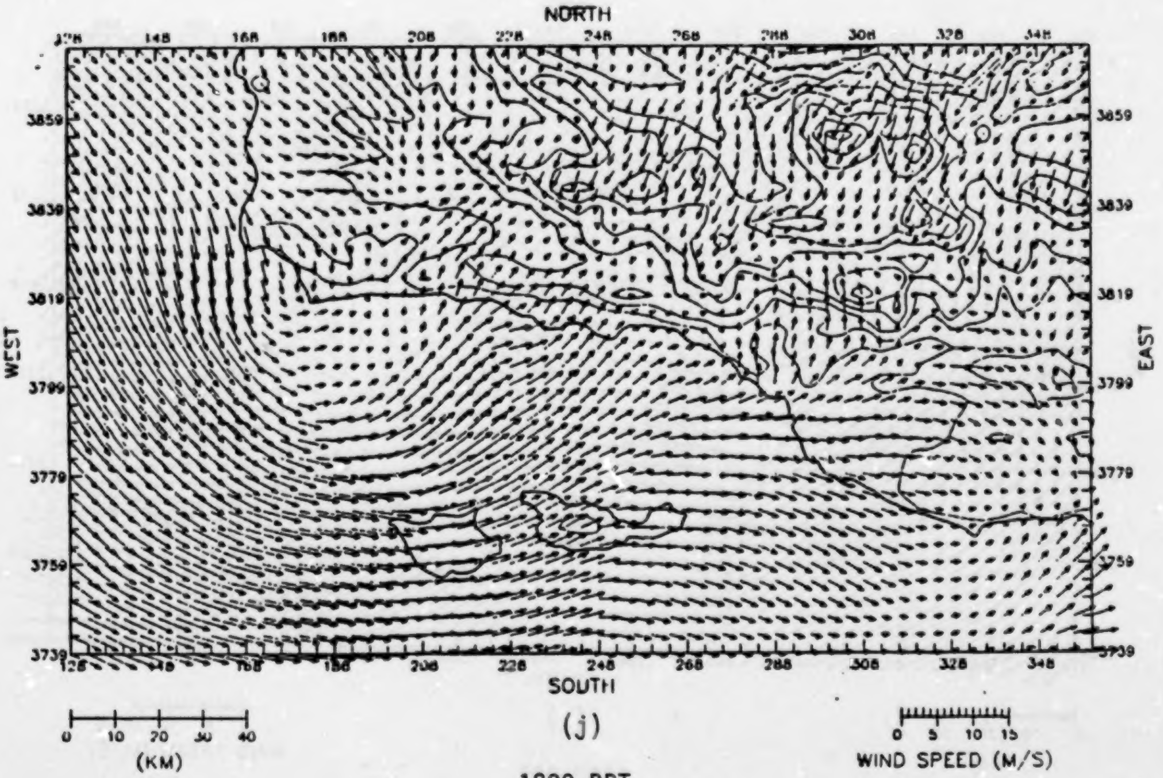
(h)

0900 PDT

FIGURE C-14. Continued.


NORTH
128
148
168
188
208
228
248
268
288
308
328
348
3859
3839
3819
3799
3779
3759
3739
WEST
EAST
SOUTH

(i)


NORTH
128
148
168
188
208
228
248
268
288
308
328
348
3859
3839
3819
3799
3779
3759
3739
WEST
EAST
SOUTH
0
10
20
30
40
(KM)
0
5
10
15
WIND SPEED (M/S)

(j)

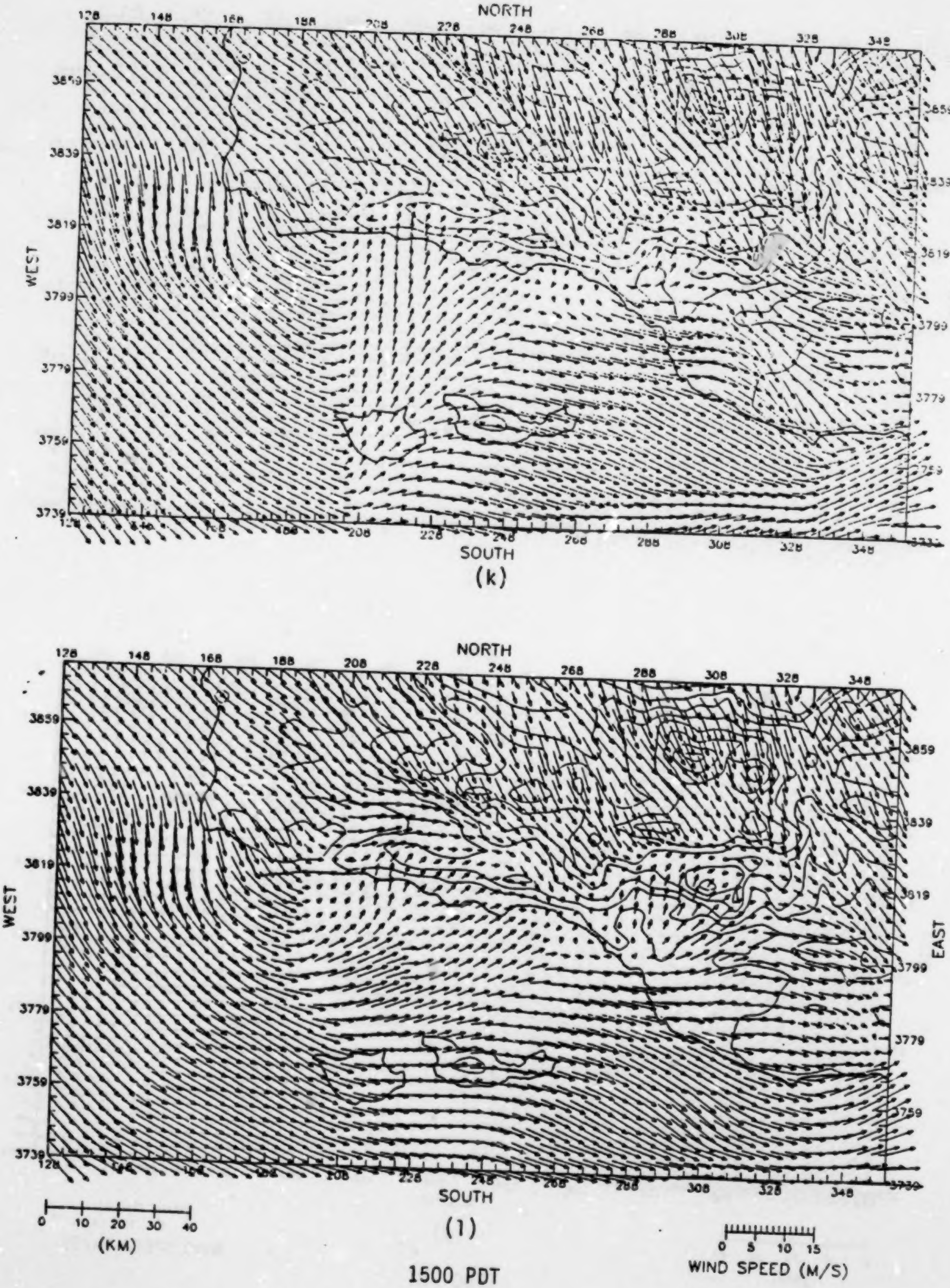
1200 PDT

FIGURE C-14. Continued.

89024

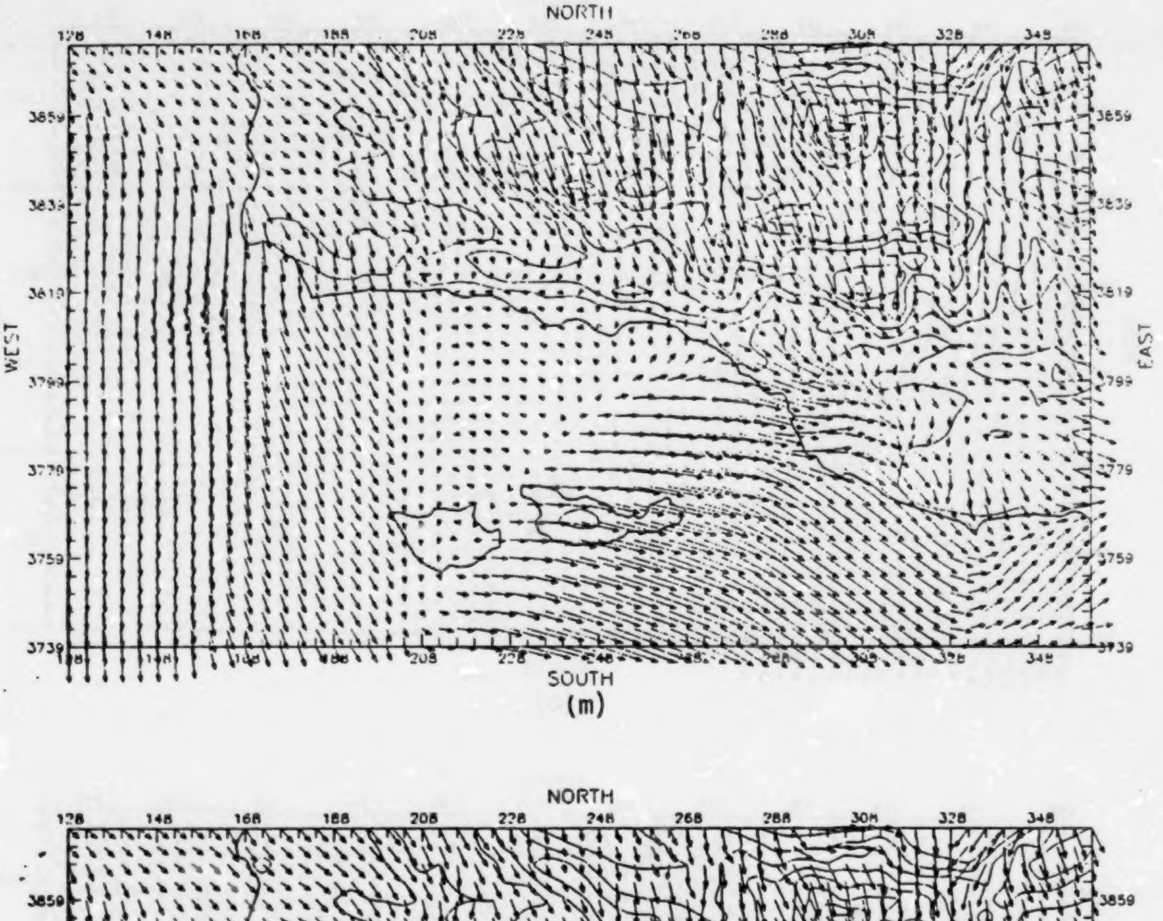
87182

207


NORTH
SOUTH
WEST
EAST
128
148
168
188
208
228
248
268
288
308
328
348
3859
3839
3819
3799
3779
3759
3739
(k)
(l)
0 10 20 30 40
(KM)
0 5 10 15
WIND SPEED (M/S)

1500 PDT

FIGURE C-14. Continued.


NORTH
SOUTH
WEST
EAST
128
148
168
188
208
228
248
268
288
308
328
348
3859
3839
3819
3799
3779
3759
3739
(m)
(n)
0 10 20 30 40
(KM)
0 5 10 15
WIND SPEED (M/S)

1800 PDT

FIGURE C-14. Continued.

89024
87182

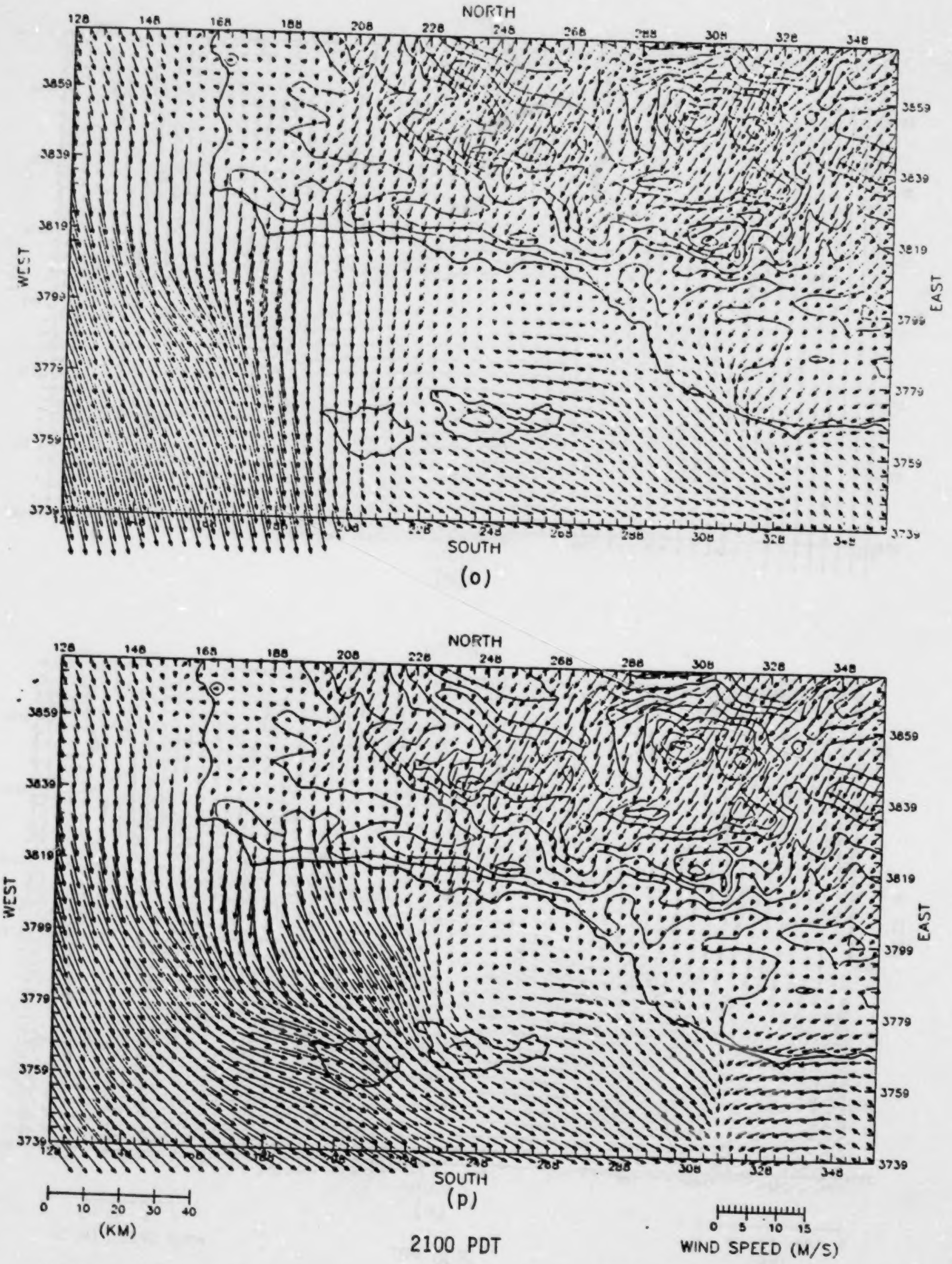

NORTH
128
148
168
188
208
228
248
268
288
308
328
348
WEST
EAST
SOUTH
3859
3839
3819
3799
3779
3759
3739
(o)
(p)
0 10 20 30 40
(KM)
2100 PDT
0 5 10 15
WIND SPEED (M/S)

FIGURE C-14. Concluded.

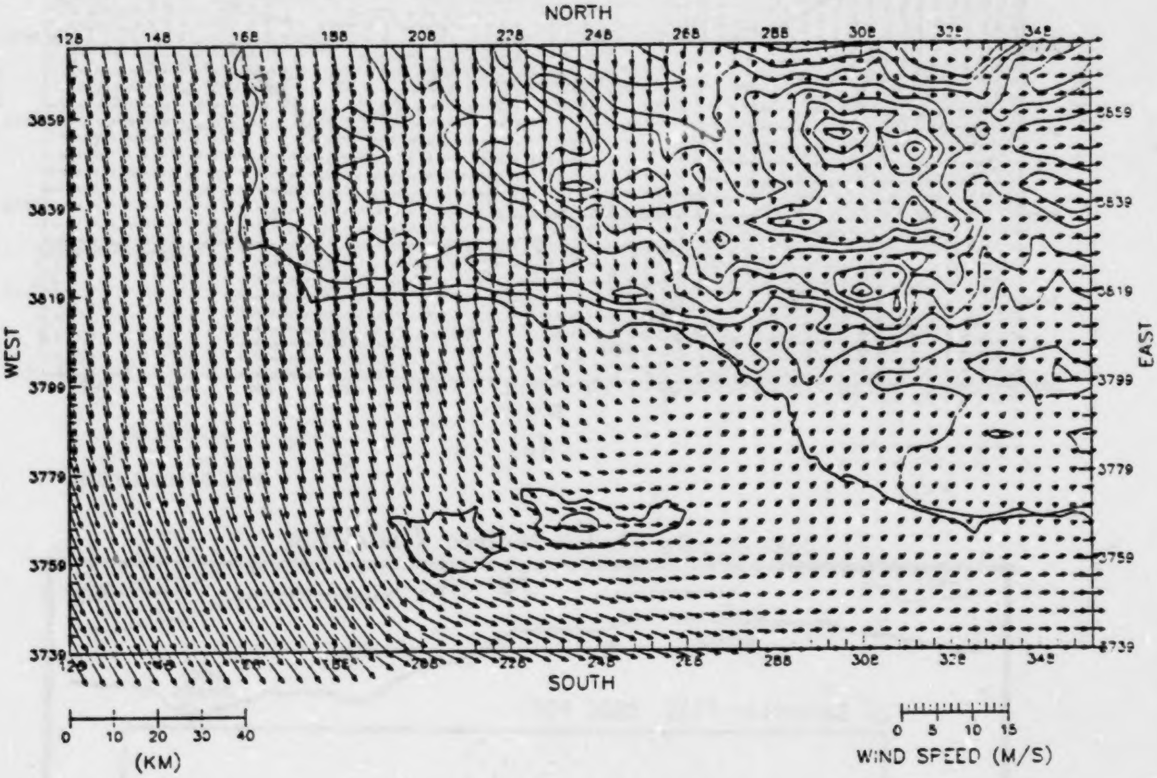
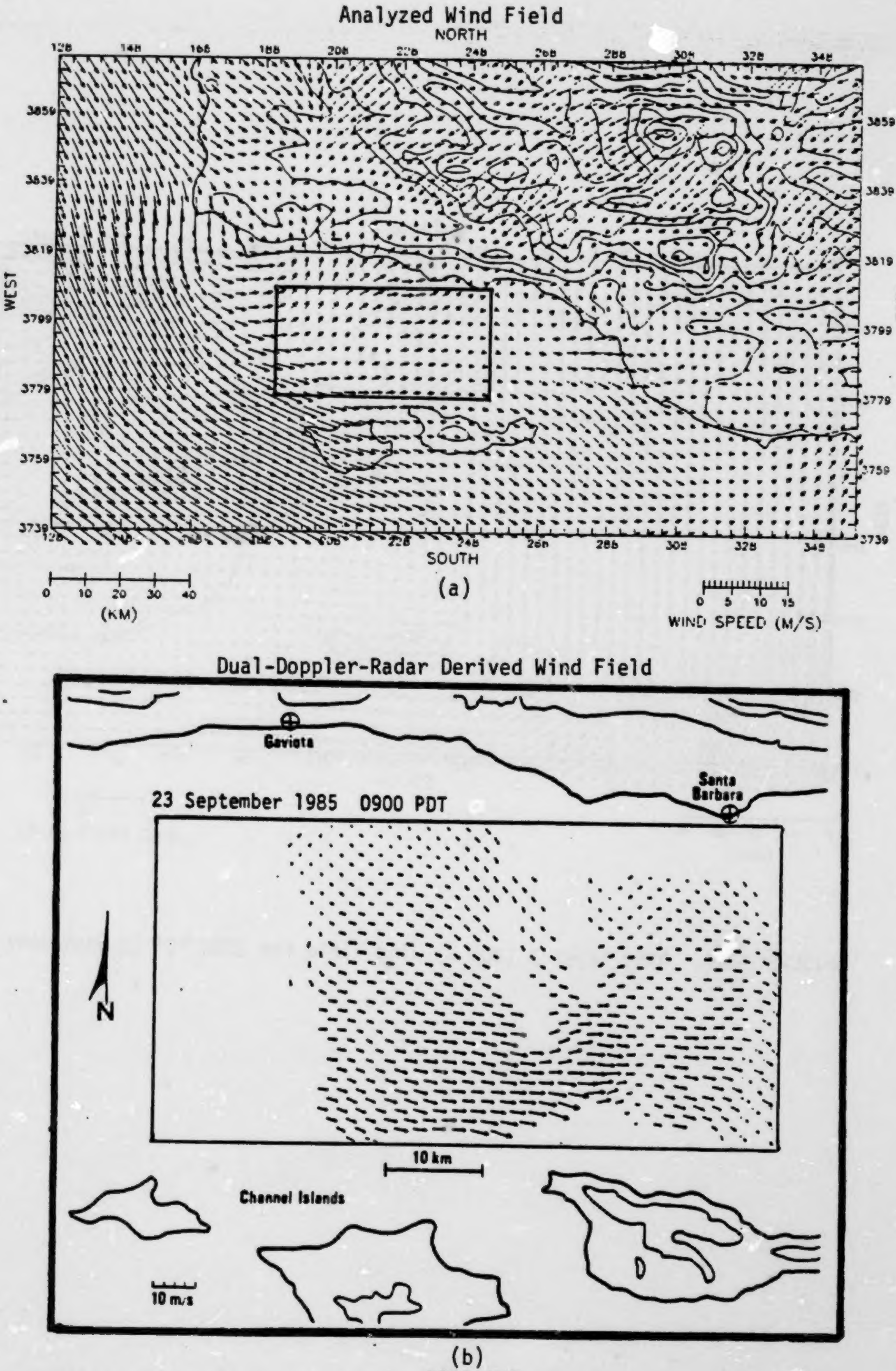

NORTH
128
148
168
188
208
228
248
268
288
308
328
348
3859
3839
3819
3799
3779
3759
3739
WEST
EAST
SOUTH
0
10
20
30
40
(KM)
0
5
10
15
WIND SPEED (M/S)

FIGURE C-15. RTN2 layer 3 (300 m) wind field for 1200 PDT 23 September.



Analyzed Wind Field
NORTH
128
148
168
188
208
228
248
268
288
308
328
348
3859
3839
3819
3799
3779
3759
3739
WEST
EAST
SOUTH
(a)
0
10
20
30
40
(KM)
0
5
10
15
WIND SPEED (M/S)
Dual-Doppler-Radar Derived Wind Field
Gaviota
Santa Barbara
23 September 1985 0900 PDT
N
10 km
Channel Islands
10 m/s

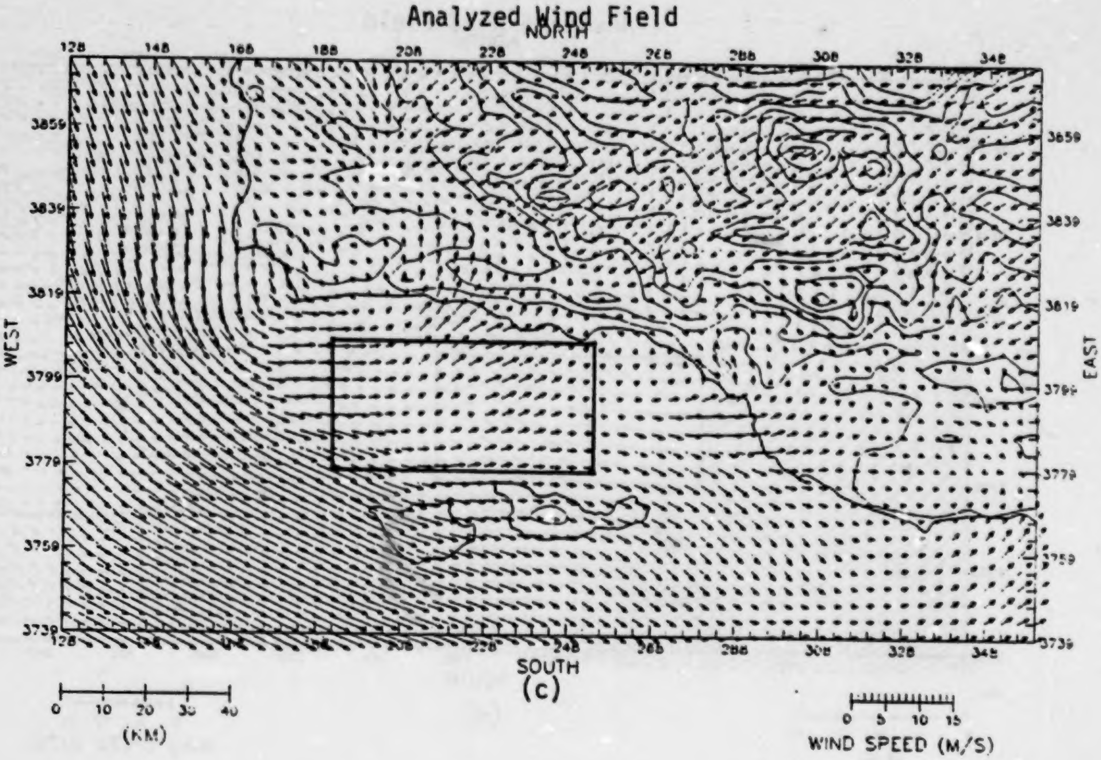
(b)
0900 PDT

FIGURE C-16. Comparison of the surface-layer diagnostic-wind-model wind fields and the dual-Doppler-radar derived wind fields for 0900, 1000, 1100, 1900, 2000, and 2100 PDT 23 September 1985.

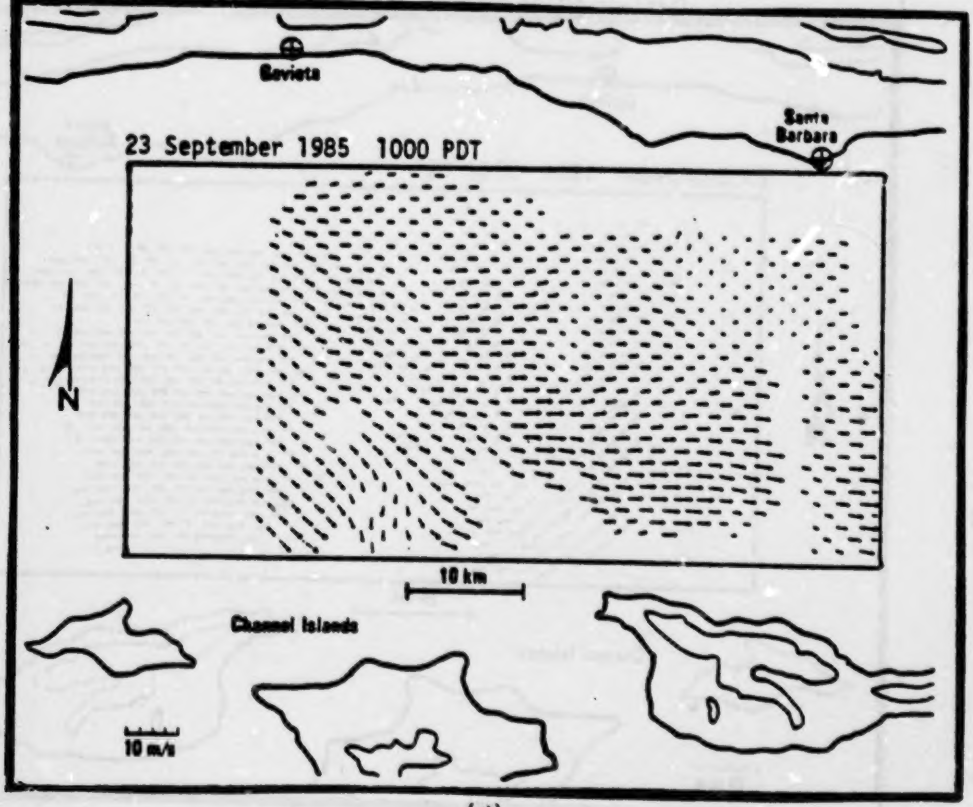
89024

87182

Analyzed Wind Field


NORTH
128
148
168
188
208
228
248
268
288
308
328
348
WEST
3859
3839
3819
3799
3779
3759
3739
EAST
SOUTH
(c)
0
10
20
30
40
(KM)
0
5
10
15
WIND SPEED (M/S)

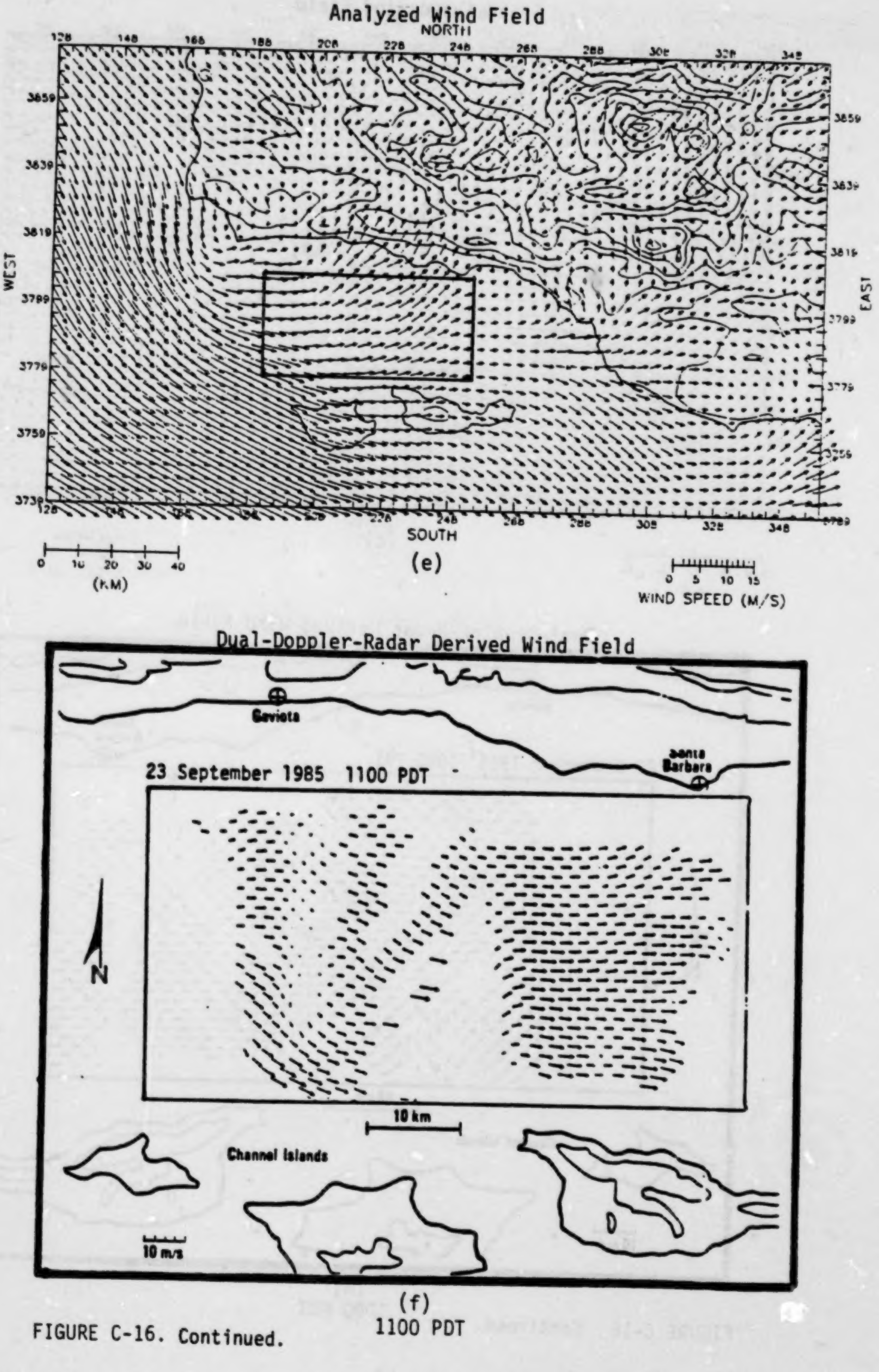
Dual-Doppler-Radar Derived Wind Field


Gaviota
Santa Barbara
N
10 km
Channel Islands
10 m/s

23 September 1985 1000 PDT

(d)
1000 PDT

FIGURE C-16. Continued.


Analyzed Wind Field
NORTH
128
148
168
188
208
228
248
268
288
308
328
348
3859
3839
3819
3799
3779
3759
3739
WEST
EAST
SOUTH
0
10
20
30
40
(KM)
0
5
10
15
WIND SPEED (M/S)
Dual-Doppler-Radar Derived Wind Field
Gaviota
Santa Barbara
23 September 1985 1100 PDT
N
10 km
Channel Islands
10 m/s

(e)

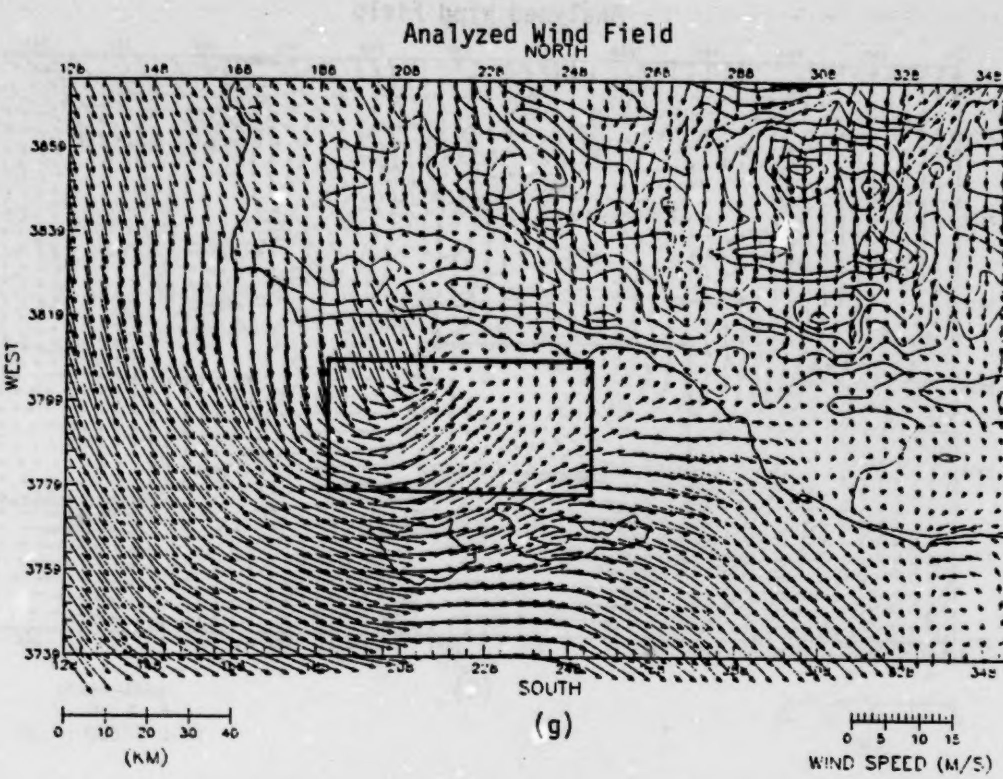
(f)
1100 PDT

FIGURE C-16. Continued.

89024

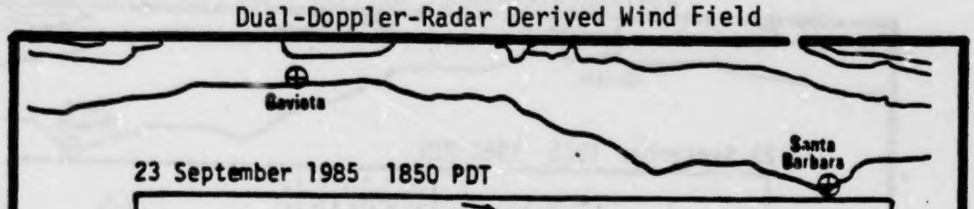
87182

2.14


Analyzed Wind Field

NORTH
128
148
168
188
208
228
248
268
288
308
328
348
3859
3839
3819
3799
3779
3759
3739
WEST
EAST
SOUTH
0
10
20
30
40
(KM)
0
5
10
15
WIND SPEED (M/S)

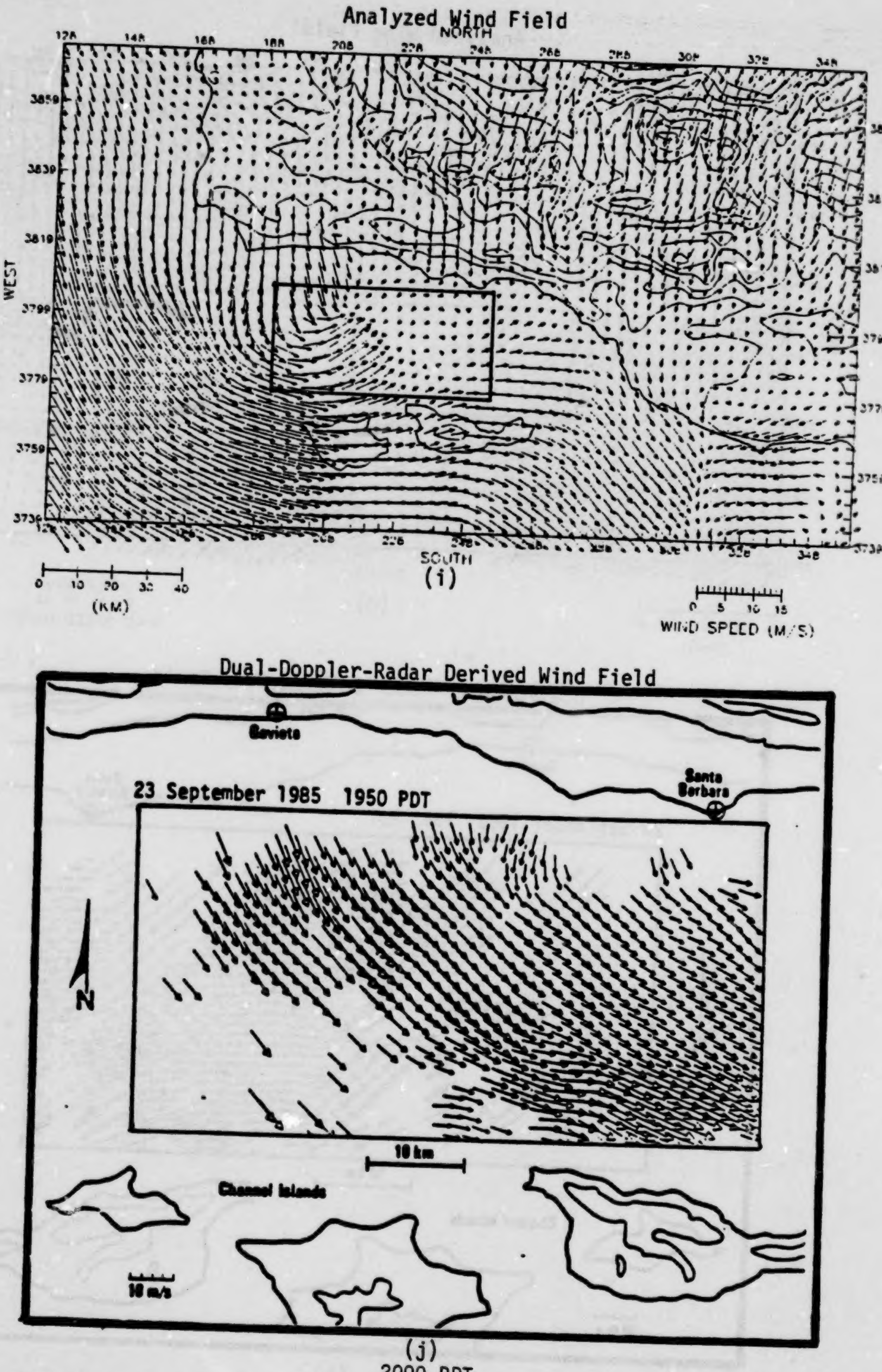
(g)


Dual-Doppler-Radar Derived Wind Field

Gaviota
Santa Barbara
23 September 1985 1850 PDT
N
10 km
Channel Islands
10 m/s

(h)
1900 PDT

FIGURE C-16. Continued.



Analyzed Wind Field

NORTH
SOUTH
WEST
EAST
(KM)
WIND SPEED (M/S)

(i)

Dual-Doppler-Radar Derived Wind Field

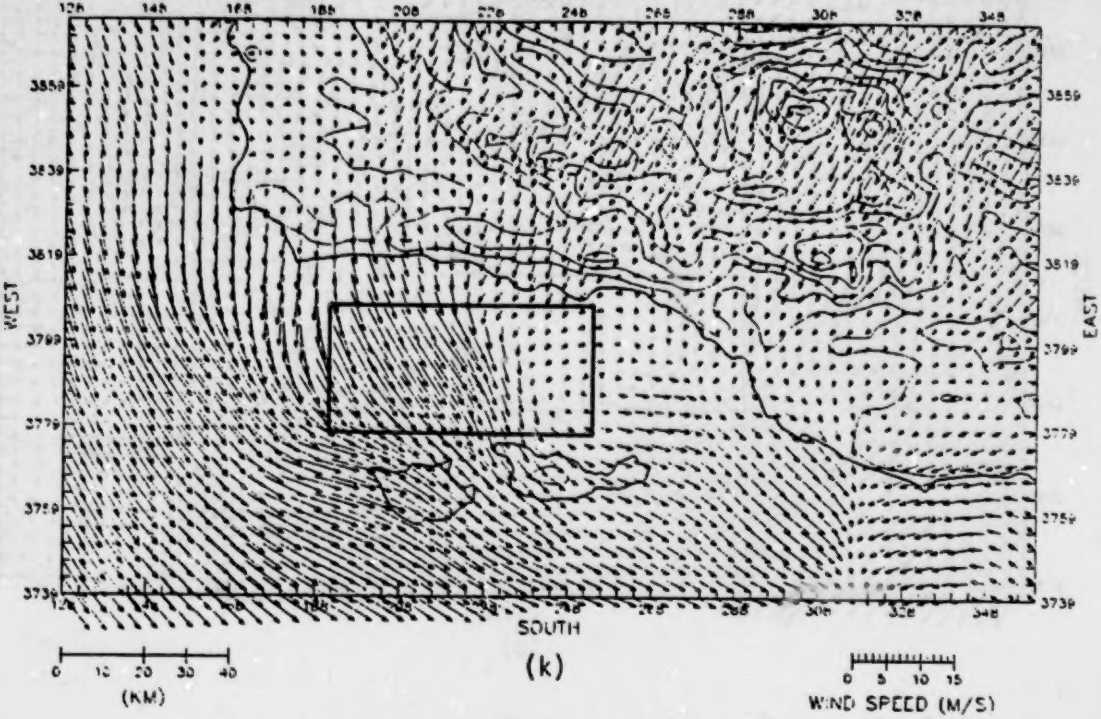
Gaviota
Santa Barbara
23 September 1985 1950 PDT
N
10 km
Channel Islands
10 m/s

(j)
2000 PDT

FIGURE C-16. Continued.

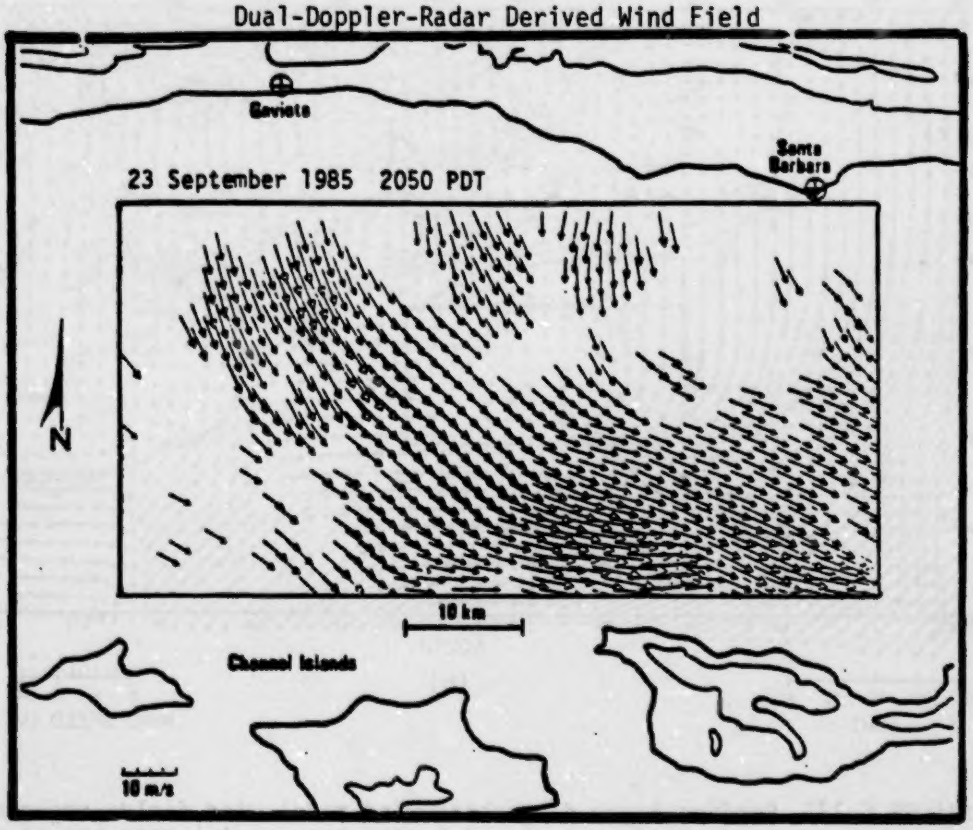
a-16

Analyzed Wind Field


NORTH
SOUTH
WEST
EAST
128
148
168
188
208
228
248
268
288
308
328
348
3859
3839
3819
3799
3779
3759
3739
0
10
20
30
40
(KM)
0 5 10 15
WIND SPEED (M/S)

(k)

Dual-Doppler-Radar Derived Wind Field


Gaviota
Santa Barbara
23 September 1985 2050 PDT
N
10 km
Channel Islands
10 m/s

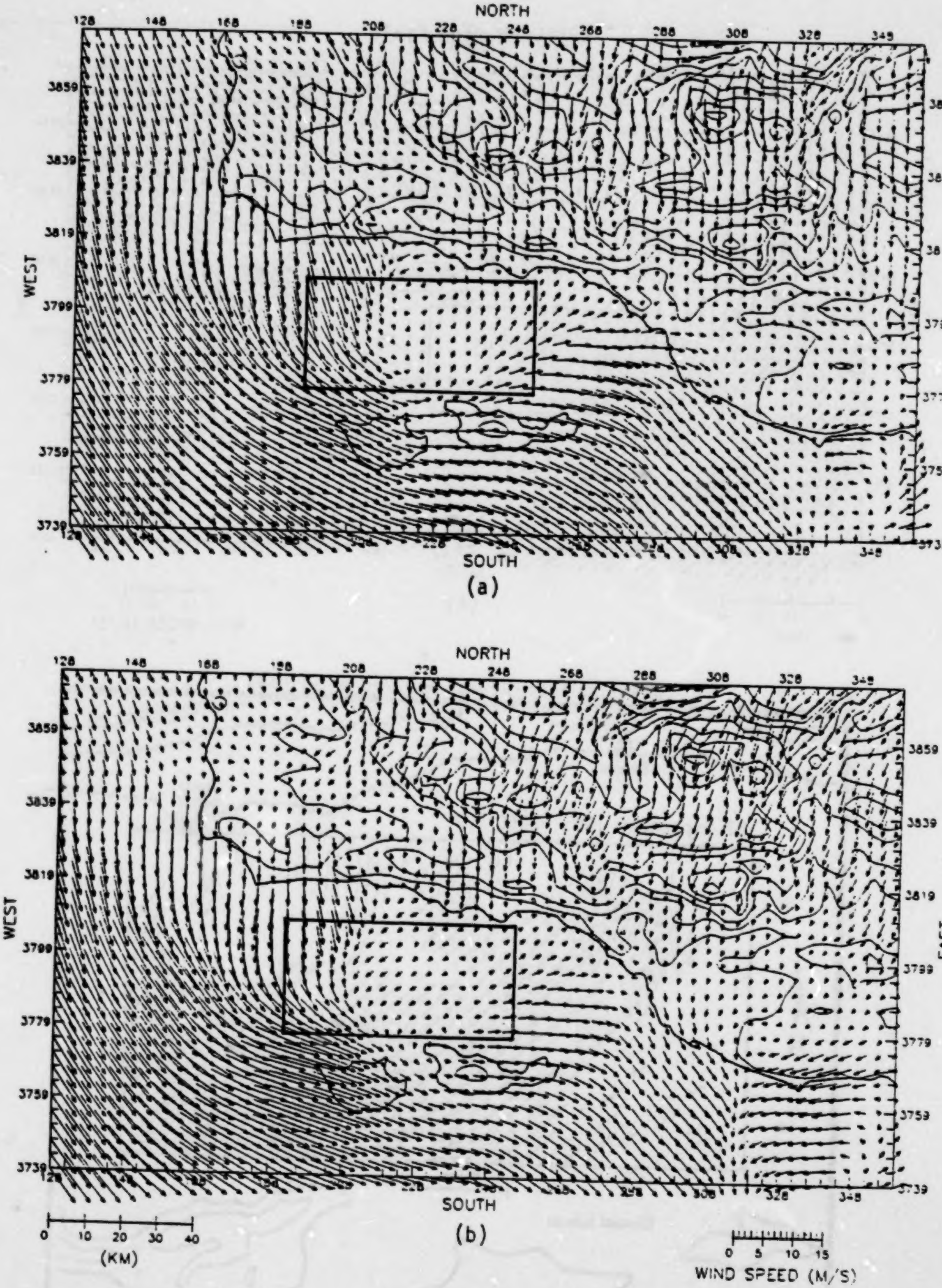
(l)
2100 PDT

FIGURE C-16. Concluded.

89024

87182

3-17


NORTH
SOUTH
WEST
EAST
128
148
168
188
208
228
248
268
288
308
328
348
3859
3839
3819
3799
3779
3759
3739
0 10 20 30 40
(KM)
0 5 10 15
WIND SPEED (M/S)

(a)

(b)

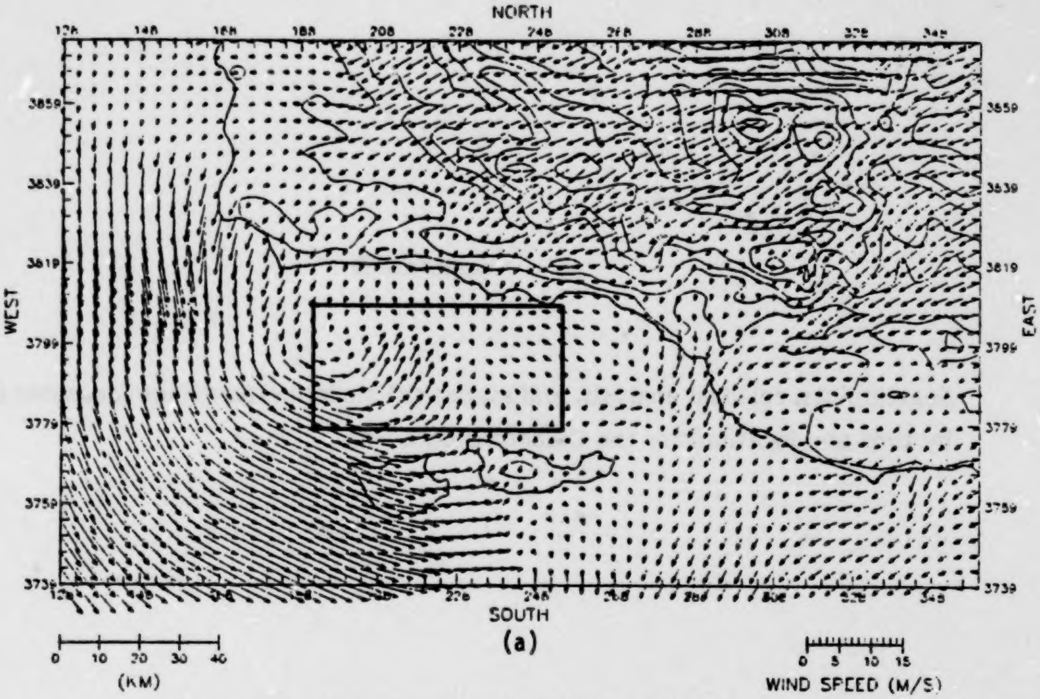
FIGURE C-17. Surface-layer diagnostic-wind-model wind fields regenerated without the Buoy F observation for (a) 1900 PDT and (b) 2000 PDT 23 September 1985.

89024

87182

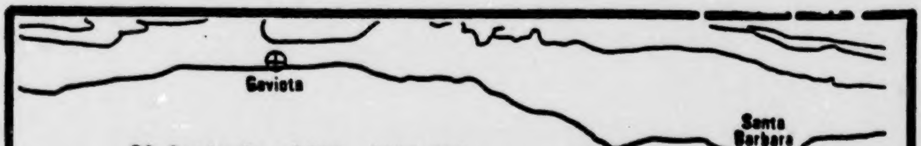
2-18

Analyzed Wind Field


NORTH
128
148
168
188
208
228
248
268
288
308
328
348
3859
3839
3819
3799
3779
3759
3739
WEST
EAST
SOUTH
0 10 20 30 40
(KM)
0 5 10 15
WIND SPEED (M/S)

(a)

Dual-Doppler-Radar Derived Wind Fields


Gaviota
Santa Barbara
20 September 1985 0650 PDT
N
10 km
Channel Islands
10 m/s

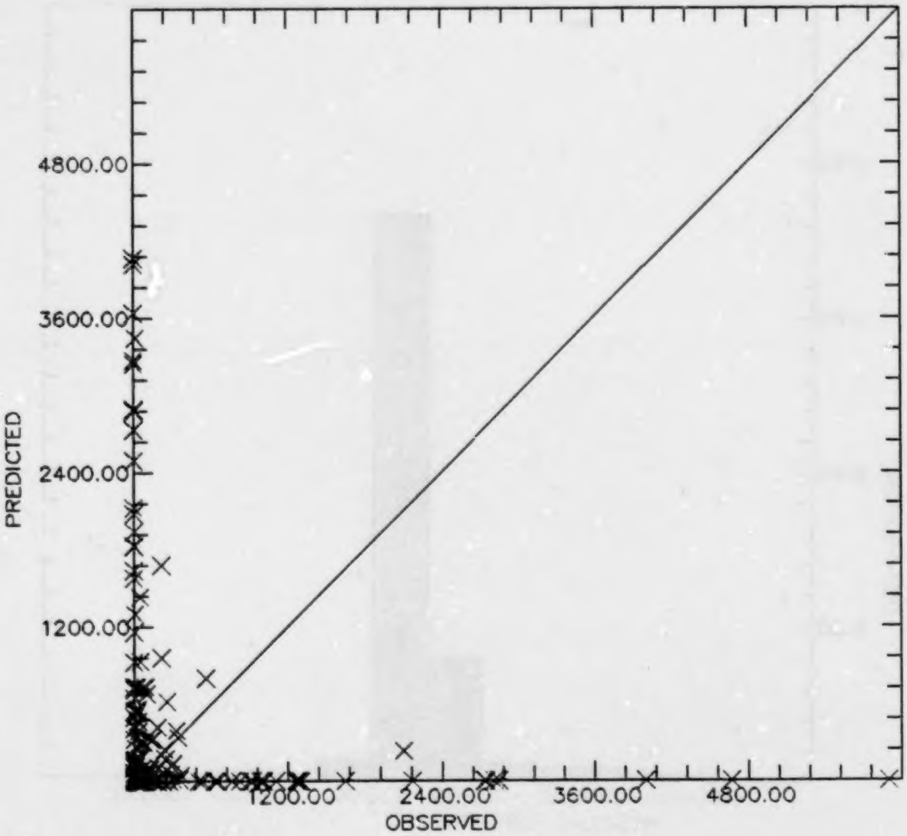
(b)

FIGURE C-18. Comparison of the surface-layer diagnostic-wind-model wind field and the dual-Doppler-radar derived wind field for 0700 PDT 20 September 1985.

Appendix D

Scatterplots, residual analysis, and statistical model performance measures (matched by time and location) for the Oklahoma data set.

VARIABLE...TRACER
BEGINNING DATE...
ENDING DATE...
OBSERVATION SOURCE...TRACER DATA
OBSERVATION ANALYSIS...OKLAHOMA EXPERIMENTS
THE PREDICTION ALGORITHM...MESOPUFF2
AVERAGING TIME...ALL DATA
STRATITFYING VARIABLE...
SAMPLE SIZE...380

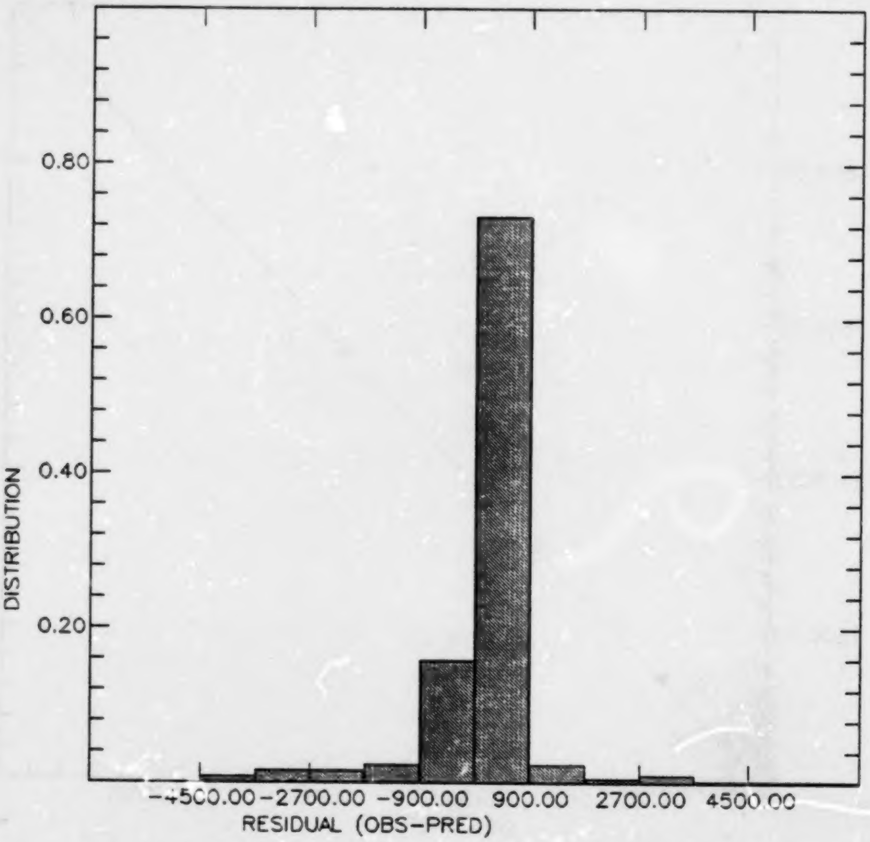


MOMENTS OF THE PROBABILITY DENSITY FUNCTION

	OBSERVED	PREDICTED
AVERAGE	143.47810	195.31310
STANDARD DEVIATION	569.34350	611.90110
SKEWNESS	6.28371	4.12973
KURTOSIS	46.41383	17.97857
OTHER MEASURES		
MEDIAN	0.00000	0.00000
UPPER QUARTILE	14.20000	13.10000
LOWER QUARTILE	0.00000	0.00000
MINIMUM VALUE	0.00000	0.00000
MAXIMUM VALUE	5896.99900	4068.99900

SKILL OF PREDICTION PARAMETERS
CORRELATION COEFFICIENT OF PREDICTED
VERSUS OBSERVED −0.059
THE BOUNDS OF THE CORRELATION AT THE
CONFIDENCE LEVEL OF 0.050 ARE
LOW BOUND −0.159 HIGH BOUND 0.042
RATIO OF OVER TO UNDER PREDICTIONS 2.193
PERCENT OF OVER PREDICTIONS
GREATER THAN 200 PERCENT OF THE
OBSERVED 20.263
PERCENT OF UNDER PREDICTIONS
LESS THAN 50 PERCENT OF THE
OBSERVED 28.684

```
VARIABLE...TRACER
BEGINNING DATE...
ENDING DATE...
OBSERVATION SOURCE...TRACER DATA
OBSERVATION ANALYSIS...OKLAHOMA EXPERIMENTS
THE PREDICTION ALGORITHM...MESOPUFF2
AVERAGING TIME...ALL DATA
STRATITFYING VARIABLE...
SAMPLE SIZE...380
```

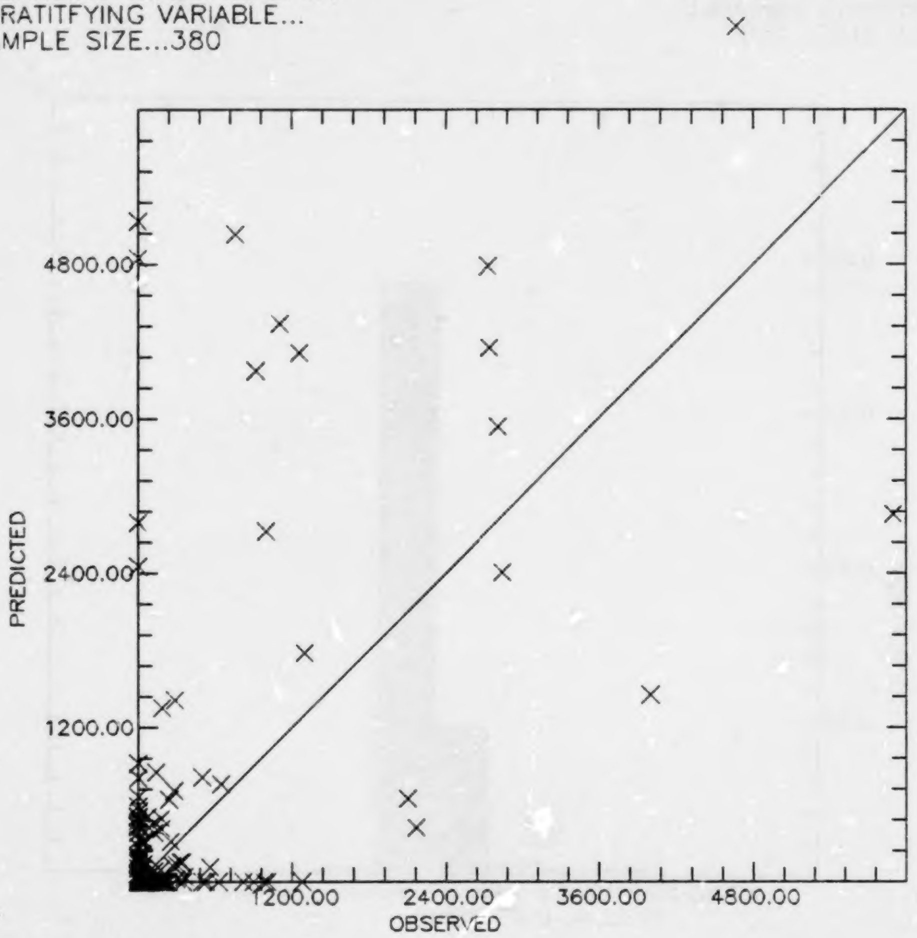


THE BINSIZE EQUALS 900.000

```
RESIDUAL ANALYSIS                              BIAS CONFIDENCE INTERVAL
                                               AT THE 0.0500 LEVEL
        AVERAGE           -51.83589            LOWER BOUND -122.5485
  STANDARD DEVIATION      860.14780            UPPER BOUND 18.8767
       SKEWNESS            0.38920
       KURTOSIS           14.65597             STD RESIDUAL CONFIDENCE INTERVAL
    OTHER MEASURES                             AT THE 0.0500 LEVEL
        MEDIAN            0.00000              LOWER BOUND 659246.9000
    UPPER QUARTILE         0.70000             UPPER BOUND 837211.2000
    LOWER QUARTILE         0.00000
     MINIMUM VALUE        -4068.99900          THE MEASURES OF GROSS ERROR
     MAXIMUM VALUE         5896.99900          THE ROOT MEAN SQUARE ERROR IS 860.58
                                               THE AVERAGE ABSOLUTE ERROR IS 313.61

                                               VARIOUS MEASURES OF RELATIVE VARIABILITY
                                               OBSERVATION COEFFICIENT OF VARIATION
                                                                     3.9682
                                               RESIDUAL COEFFICIENT OF VARIATION
                                                                     5.9950
                                               RATIO OF RESIDUAL TO OBSERVED ST. DEV.
                                                                     1.5108
```

VARIABLE...TRACER
BEGINNING DATE...
ENDING DATE...
OBSERVATION SOURCE...TRACER DATA
OBSERVATION ANALYSIS...OKLAHOMA EXPERIMENTS
THE PREDICTION ALGORITHM...MESOPLUME
AVERAGING TIME...ALL DATA
STRATITFYING VARIABLE...
SAMPLE SIZE...380



MOMENTS OF THE PROBABILITY DENSITY FUNCTION

	OBSERVED	PREDICTED
AVERAGE	143.47810	252.19190
STANDARD DEVIATION	569.34350	988.32770
SKEWNESS	6.28371	6.00494
KURTOSIS	46.41383	44.71675
OTHER MEASURES		
MEDIAN	0.00000	0.00000
UPPER QUARTILE	14.20000	5.90000
LOWER QUARTILE	0.00000	0.00000
MINIMUM VALUE	0.00000	0.00000
MAXIMUM VALUE	5896.99900	10813.29000

SKILL OF PREDICTION PARAMETERS

CORRELATION COEFFICIENT OF PREDICTED VERSUS OBSERVED 0.593

THE BOUNDS OF THE CORRELATION AT THE CONFIDENCE LEVEL OF 0.050 ARE

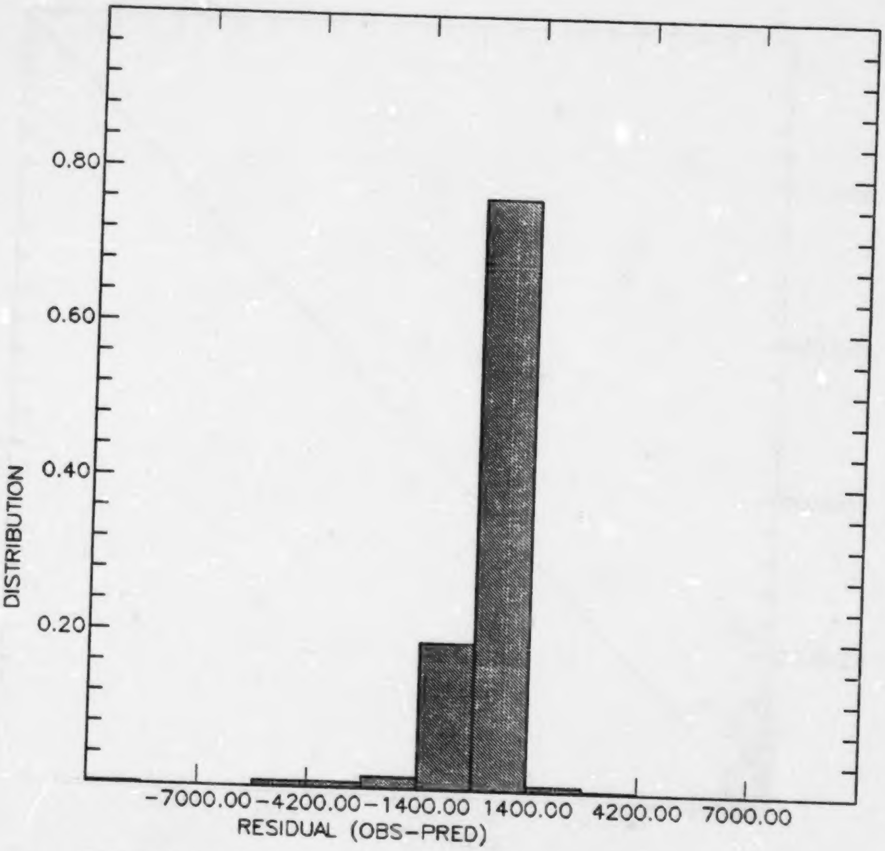
LOW BOUND 0.523 HIGH BOUND 0.654

RATIO OF OVER TO UNDER PREDICTIONS 1.901

PERCENT OF OVER PREDICTIONS GREATER THAN 200 PERCENT OF THE OBSERVED 20.263

PERCENT OF UNDER PREDICTIONS LESS THAN 50 PERCENT OF THE OBSERVED 32.895

```
VARIABLE...TRACER
BEGINNING DATE...
ENDING DATE...
OBSERVATION SOURCE...TRACER DATA
OBSERVATION ANALYSIS...OKLAHOMA EXPERIMENTS
THE PREDICTION ALGORITHM...MESOPLUME
AVERAGING TIME...ALL DATA
STRATITFYING VARIABLE...
SAMPLE SIZE...380
```

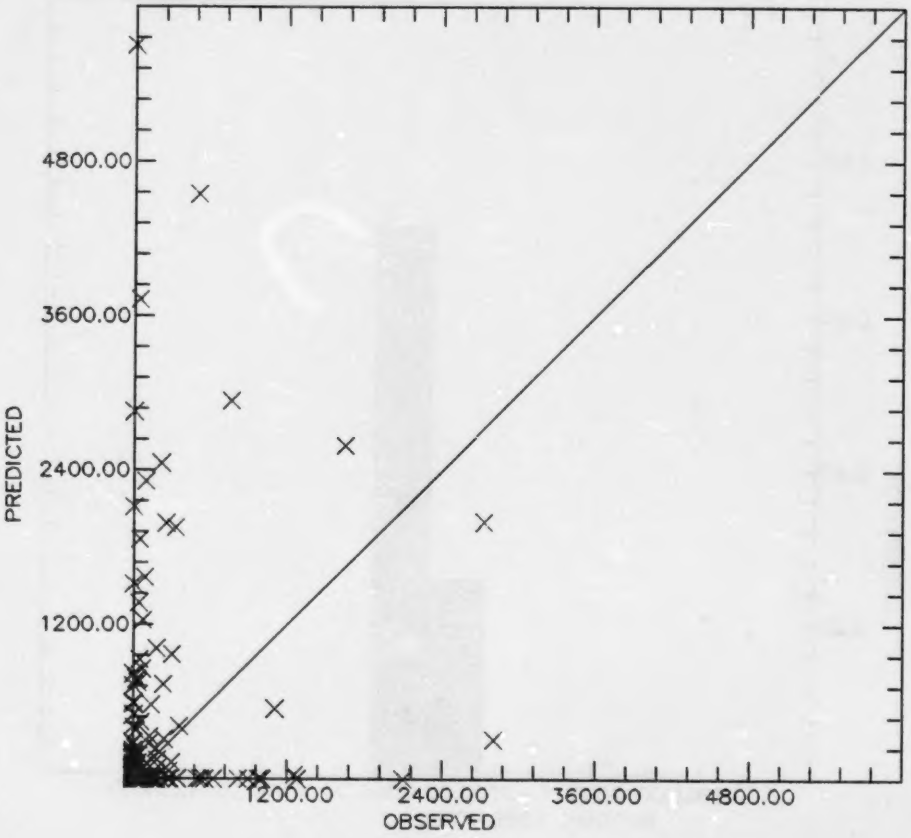


THE BINSIZE EQUALS 1400.000

```
RESIDUAL ANALYSIS                        BIAS CONFIDENCE INTERVAL
                                         AT THE 0.0500 LEVEL
          AVERAGE      -108.71580        LOWER BOUND -205.2141
 STANDARD DEVIATION     796.13530        UPPER BOUND -12.2176
          SKEWNESS       -5.80674
          KURTOSIS       53.98298        STD RESIDUAL CONFIDENCE INTERVAL
   OTHER MEASURES                        AT THE 0.0500 LEVEL
           MEDIAN        0.00000         LOWER BOUND 564775.3000
     UPPER QUARTILE      2.00000         UPPER BOUND 717236.9000
     LOWER QUARTILE      0.00000
      MINIMUM VALUE  -9166.29700         THE MEASURES OF GROSS ERROR
      MAXIMUM VALUE   3037.49900         THE ROOT MEAN SQUARE ERROR IS 802.49
                                         THE AVERAGE ABSOLUTE ERROR IS 221.23

                                         VARIOUS MEASURES OF RELATIVE VARIABILITY
                                         OBSERVATION COEFFICIENT OF VARIATION
                                                                     3.9682
                                         RESIDUAL COEFFICIENT OF VARIATION
                                                                     5.5488
                                         RATIO OF RESIDUAL TO OBSERVED ST. DEV.
                                                                     1.3983
```

VARIABLE...TRACER
BEGINNING DATE...
ENDING DATE...
OBSERVATION SOURCE...TRACER DATA
OBSERVATION ANALYSIS...OKLAHOMA EXPERIMENTS
THE PREDICTION ALGORITHM...MSPUFF
AVERAGING TIME...ALL DATA
STRATITFYING VARIABLE...
SAMPLE SIZE...380

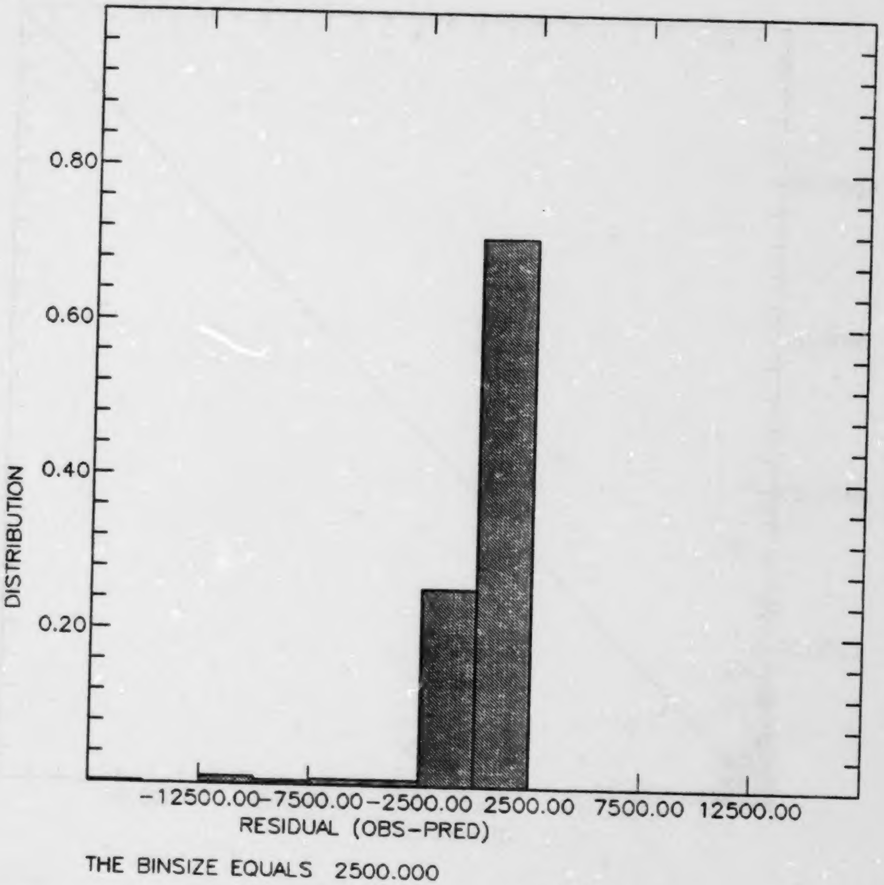


MOMENTS OF THE PROBABILITY DENSITY FUNCTION

	OBSERVED	PREDICTED
AVERAGE	143.47810	469.43160
STANDARD DEVIATION	569.34350	2123.26300
SKEWNESS	6.28371	6.32284
KURTOSIS	46.41383	43.15931
OTHER MEASURES		
MEDIAN	0.00000	0.00000
UPPER QUARTILE	14.20000	10.00000
LOWER QUARTILE	0.00000	0.00000
MINIMUM VALUE	0.00000	0.00000
MAXIMUM VALUE	5896.99900	20280.79000

SKILL OF PREDICTION PARAMETERS
CORRELATION COEFFICIENT OF PREDICTED
VERSUS OBSERVED 0.759
THE BOUNDS OF THE CORRELATION AT THE
CONFIDENCE LEVEL OF 0.050 ARE
LOW BOUND 0.713 HIGH BOUND 0.798
RATIO OF OVER TO UNDER PREDICTIONS 2.167
PERCENT OF OVER PREDICTIONS
GREATER THAN 200 PERCENT OF THE
OBSERVED 27.632
PERCENT OF UNDER PREDICTIONS
LESS THAN 50 PERCENT OF THE
OBSERVED 31.053

VARIABLE...TRACER
BEGINNING DATE...
ENDING DATE...
OBSERVATION SOURCE...TRACER DATA
OBSERVATION ANALYSIS...OKLAHOMA EXPERIMENTS
THE PREDICTION ALGORITHM...MSPUFF
AVERAGING TIME...ALL DATA
STRATITFYING VARIABLE...
SAMPLE SIZE...380



THE BINSIZE EQUALS 2500.000

RESIDUAL ANALYSIS

AVERAGE	−325.95940
STANDARD DEVIATION	1731.43700
SKEWNESS	−6.14949
KURTOSIS	43.29997
OTHER MEASURES	
MEDIAN	0.00000
UPPER QUARTILE	0.80000
LOWER QUARTILE	−2.60000
MINIMUM VALUE	−17443.79000
MAXIMUM VALUE	2499.19800

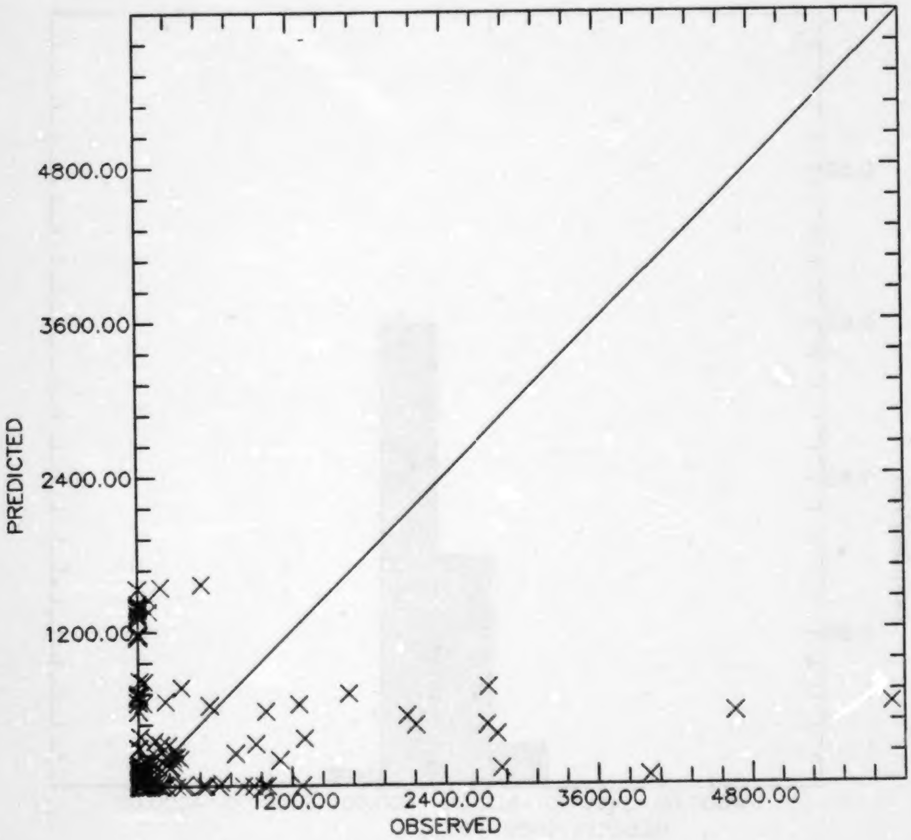
BIAS CONFIDENCE INTERVAL
AT THE 0.0500 LEVEL
LOWER BOUND −511.9418
UPPER BOUND −139.9772

STD RESIDUAL CONFIDENCE INTERVAL
AT THE 0.0500 LEVEL
LOWER BOUND 2671257.00
UPPER BOUND 3392364.00

THE MEASURES OF GROSS ERROR
THE ROOT MEAN SQUARE ERROR IS 1759.61
THE AVERAGE ABSOLUTE ERROR IS 428.80

VARIOUS MEASURES OF RELATIVE VARIABILITY
OBSERVATION COEFFICIENT OF VARIATION
3.9682
RESIDUAL COEFFICIENT OF VARIATION
12.0676
RATIO OF RESIDUAL TO OBSERVED ST. DEV.
3.0411

VARIABLE...TRACER
BEGINNING DATE...
ENDING DATE...
OBSERVATION SOURCE...TRACER DATA
OBSERVATION ANALYSIS...OKLAHOMA EXPERIMENTS
THE PREDICTION ALGORITHM...RTM2
AVERAGING TIME...ALL DATA
STRATITFYING VARIABLE...
SAMPLE SIZE...380



MOMENTS OF THE PROBABILITY DENSITY FUNCTION

	OBSERVED	PREDICTED
AVERAGE	143.47810	139.05040
STANDARD DEVIATION	569.34350	330.28980
SKEWNESS	6.28371	2.87937
KURTOSIS	46.41383	7.61248
OTHER MEASURES		
MEDIAN	0.00000	0.00000
UPPER QUARTILE	14.20000	79.69999
LOWER QUARTILE	0.00000	0.00000
MINIMUM VALUE	0.00000	0.00000
MAXIMUM VALUE	5896.99900	1565.99900

SKILL OF PREDICTION PARAMETERS
CORRELATION COEFFICIENT OF PREDICTED VERSUS OBSERVED 0.179
THE BOUNDS OF THE CORRELATION AT THE CONFIDENCE LEVEL OF 0.050 ARE
LOW BOUND 0.080 HIGH BOUND 0.275
RATIO OF OVER TO UNDER PREDICTIONS 3.086
PERCENT OF OVER PREDICTIONS GREATER THAN 200 PERCENT OF THE OBSERVED 31.579
PERCENT OF UNDER PREDICTIONS LESS THAN 50 PERCENT OF THE OBSERVED 21.053

2-27

```
VARIABLE...TRACER
BEGINNING DATE...
ENDING DATE...
OBSERVATION SOURCE...TRACER DATA
OBSERVATION ANALYSIS...OKLAHOMA EXPERIMENTS
THE PREDICTION ALGORITHM...RTM2
AVERAGING TIME...ALL DATA
STRATITFYING VARIABLE...
SAMPLE SIZE...380
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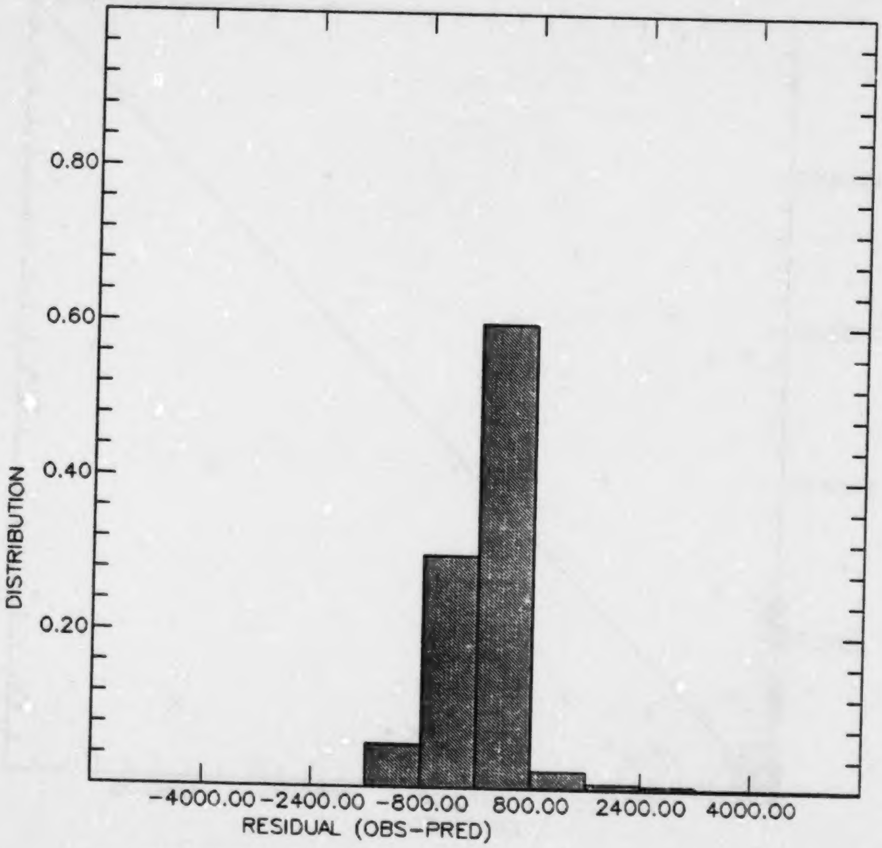


THE BINSIZE EQUALS 800.000

```
RESIDUAL ANALYSIS
        AVERAGE              4.42689
   STANDARD DEVIATION      604.91580
        SKEWNESS             3.52313
        KURTOSIS            26.61474
   OTHER MEASURES
        MEDIAN               0.00000
    UPPER QUARTILE           0.00000
    LOWER QUARTILE          -7.30000
     MINIMUM VALUE       -1534.79900
     MAXIMUM VALUE        5274.49800
```

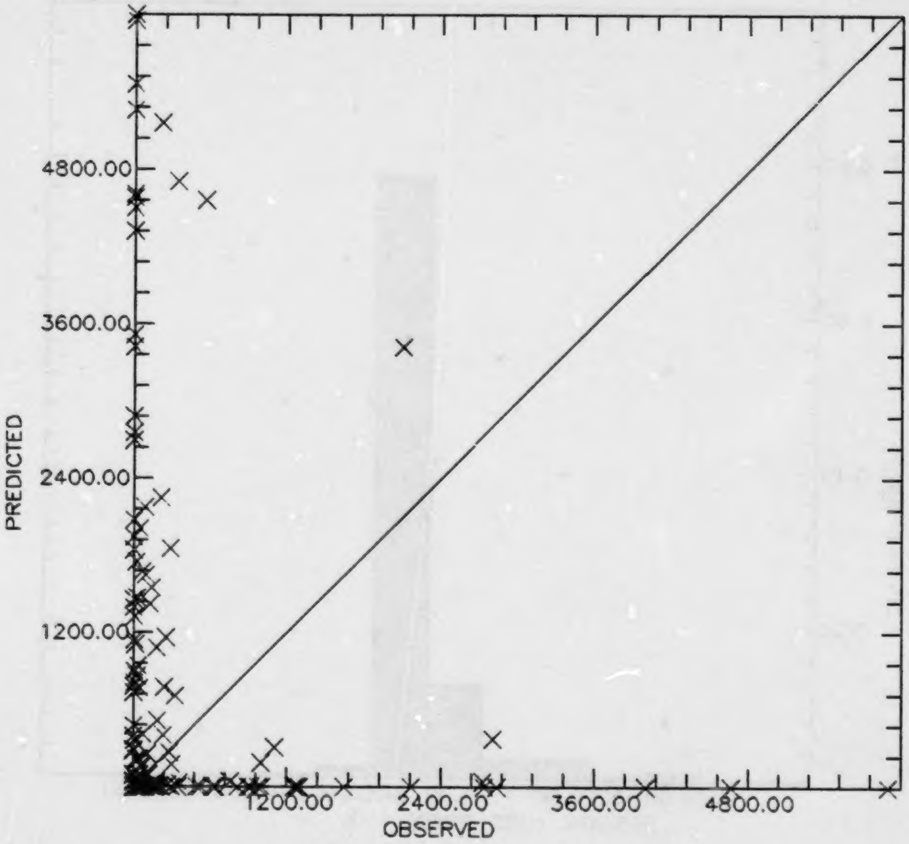
```
BIAS CONFIDENCE INTERVAL
AT THE 0.0500 LEVEL
LOWER BOUND -51.2604
UPPER BOUND 60.1142

STD RESIDUAL CONFIDENCE INTERVAL
AT THE 0.0500 LEVEL
LOWER BOUND 326055.5000
UPPER BOUND 414074.5000

THE MEASURES OF GROSS ERROR
THE ROOT MEAN SQUARE ERROR IS 604.14
THE AVERAGE ABSOLUTE ERROR IS 213.02

VARIOUS MEASURES OF RELATIVE VARIABILITY
OBSERVATION COEFFICIENT OF VARIATION
                         3.9682
RESIDUAL COEFFICIENT OF VARIATION
                         4.2161
RATIO OF RESIDUAL TO OBSERVED ST. DEV.
                         1.0625
```

VARIABLE...TRACER
BEGINNING DATE...
ENDING DATE...
OBSERVATION SOURCE...TRACER DATA
OBSERVATION ANALYSIS...OKLAHOMA EXPERIMENTS
THE PREDICTION ALGORITHM...RADM
AVERAGING TIME...ALL DATA
STRATITFYING VARIABLE...
SAMPLE SIZE...380



MOMENTS OF THE PROBABILITY DENSITY FUNCTION

	OBSERVED	PREDICTED
AVERAGE	143.47810	508.24430
STANDARD DEVIATION	569.34350	1651.75000
SKEWNESS	6.28371	4.55784
KURTOSIS	46.41383	23.70582
OTHER MEASURES		
MEDIAN	0.00000	0.00000
UPPER QUARTILE	14.20000	0.00000
LOWER QUARTILE	0.00000	0.00000
MINIMUM VALUE	0.00000	0.00000
MAXIMUM VALUE	5896.99900	12879.49000

SKILL OF PREDICTION PARAMETERS
CORRELATION COEFFICIENT OF PREDICTED
VERSUS OBSERVED −0.027
THE BOUNDS OF THE CORRELATION AT THE
CONFIDENCE LEVEL OF 0.050 ARE
LOW BOUND −0.127 HIGH BOUND 0.074
RATIO OF OVER TO UNDER PREDICTIONS 2.248
PERCENT OF OVER PREDICTIONS
GREATER THAN 200 PERCENT OF THE
OBSERVED 18.421
PERCENT OF UNDER PREDICTIONS
LESS THAN 50 PERCENT OF THE
OBSERVED 29.474

```
VARIABLE...TRACER
BEGINNING DATE...
ENDING DATE...
OBSERVATION SOURCE...TRACER DATA
OBSERVATION ANALYSIS...OKLAHOMA EXPERIMENTS
THE PREDICTION ALGORITHM...RADM
AVERAGING TIME...ALL DATA
STRATITFYING VARIABLE...
SAMPLE SIZE...380
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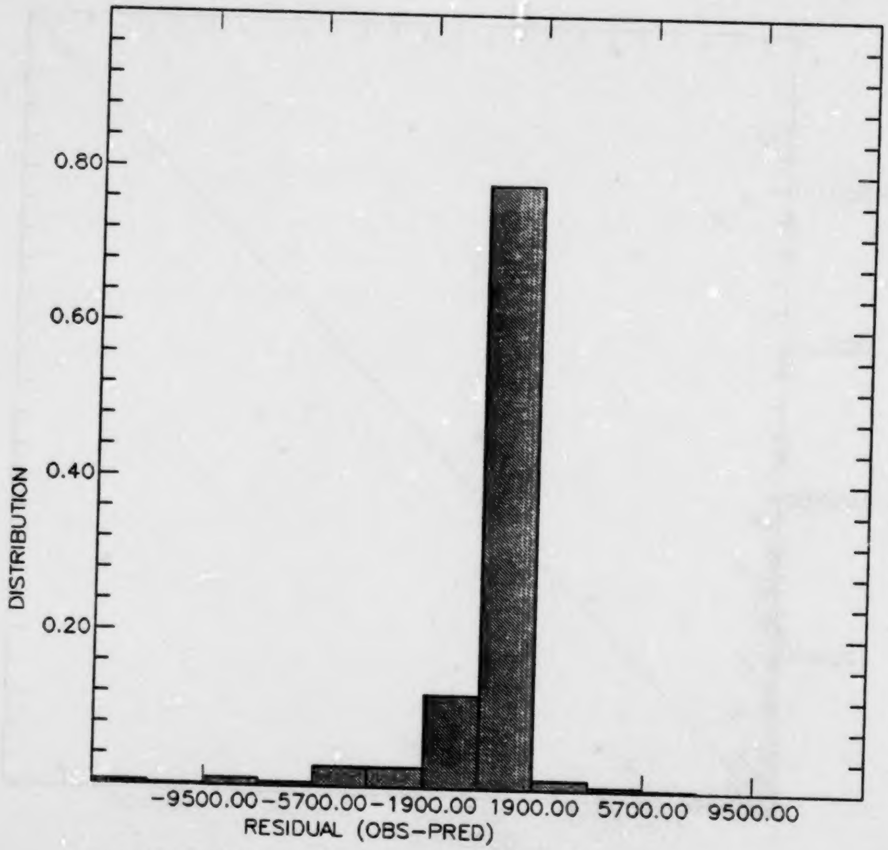
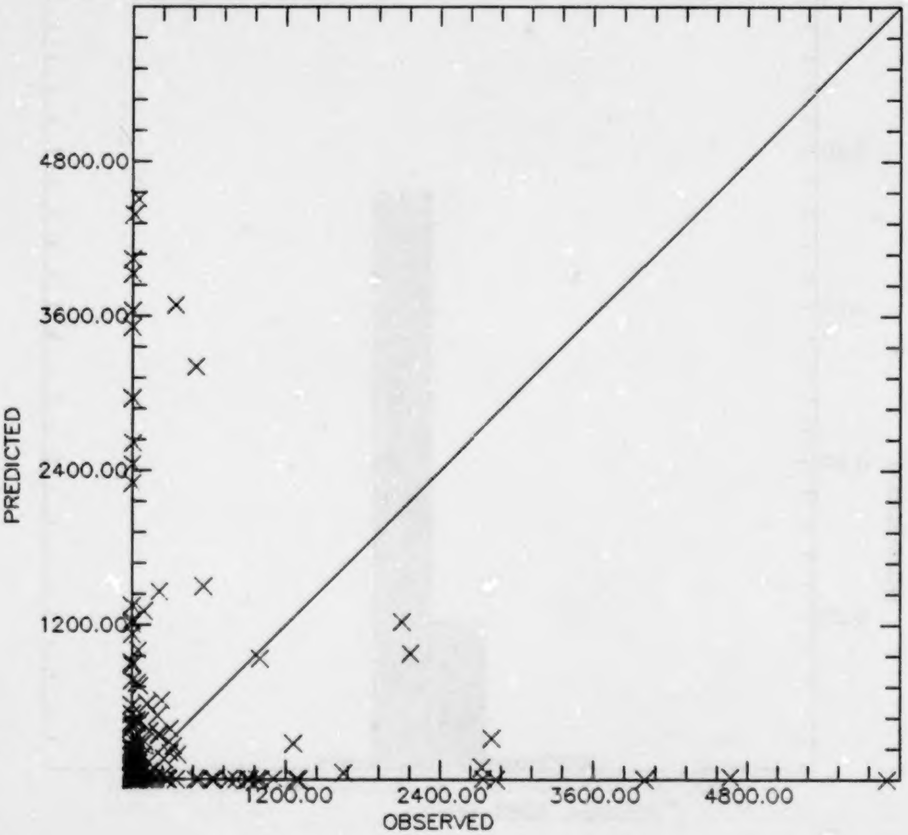


```
THE BINSIZE EQUALS  1899.999

RESIDUAL ANALYSIS                              BIAS CONFIDENCE INTERVAL
         AVERAGE          -364.77010           AT THE 0.0500 LEVEL
  STANDARD DEVIATION       1761.33700          LOWER BOUND -512.5834
         SKEWNESS          -3.61930            UPPER BOUND -216.9570
         KURTOSIS          19.55924
   OTHER MEASURES                              STD RESIDUAL CONFIDENCE INTERVAL
         MEDIAN           0.00000              AT THE 0.0500 LEVEL
    UPPER QUARTILE         0.80000             LOWER BOUND 2764312.00
    LOWER QUARTILE         0.00000             UPPER BOUND 3510541.00
     MINIMUM VALUE        -12879.09000
     MAXIMUM VALUE         5896.99900          THE MEASURES OF GROSS ERROR
                                               THE ROOT MEAN SQUARE ERROR IS 1796.44
                                               THE AVERAGE ABSOLUTE ERROR IS 608.97

                                               VARIOUS MEASURES OF RELATIVE VARIABILITY
                                               OBSERVATION COEFFICIENT OF VARIATION
                                                                   3.9682
                                               RESIDUAL COEFFICIENT OF VARIATION
                                                                   12.2760
                                               RATIO OF RESIDUAL TO OBSERVED ST. DEV.
                                                                   3.0936
```

VARIABLE...TRACER
BEGINNING DATE...
ENDING DATE...
OBSERVATION SOURCE...TRACER DATA
OBSERVATION ANALYSIS...OKLAHOMA EXPERIMENTS
THE PREDICTION ALGORITHM...ARRPA
AVERAGING TIME...ALL DATA
STRATITFYING VARIABLE...
SAMPLE SIZE...380



MOMENTS OF THE PROBABILITY DENSITY FUNCTION

	OBSERVED	PREDICTED
AVERAGE	143.47810	257.08100
STANDARD DEVIATION	569.34350	995.24040
SKEWNESS	6.28371	6.20658
KURTOSIS	46.41383	45.97171
OTHER MEASURES		
MEDIAN	0.00000	0.00000
UPPER QUARTILE	14.20000	9.60000
LOWER QUARTILE	0.00000	0.00000
MINIMUM VALUE	0.00000	0.00000
MAXIMUM VALUE	5896.99900	10242.29000

SKILL OF PREDICTION PARAMETERS
CORRELATION COEFFICIENT OF PREDICTED
VERSUS OBSERVED 0.009
THE BOUNDS OF THE CORRELATION AT THE
CONFIDENCE LEVEL OF 0.050 ARE
LOW BOUND -0.092 HIGH BOUND 0.110
RATIO OF OVER TO UNDER PREDICTIONS 2.167
PERCENT OF OVER PREDICTIONS
GREATER THAN 200 PERCENT OF THE
OBSERVED 20.789
PERCENT OF UNDER PREDICTIONS
LESS THAN 50 PERCENT OF THE
OBSERVED 28.947

```
VARIABLE...TRACER
BEGINNING DATE...
ENDING DATE...
OBSERVATION SOURCE...TRACER DATA
OBSERVATION ANALYSIS...OKLAHOMA EXPERIMENTS
THE PREDICTION ALGORITHM...ARRPA
AVERAGING TIME...ALL DATA
STRATITFYING VARIABLE...
SAMPLE SIZE...380
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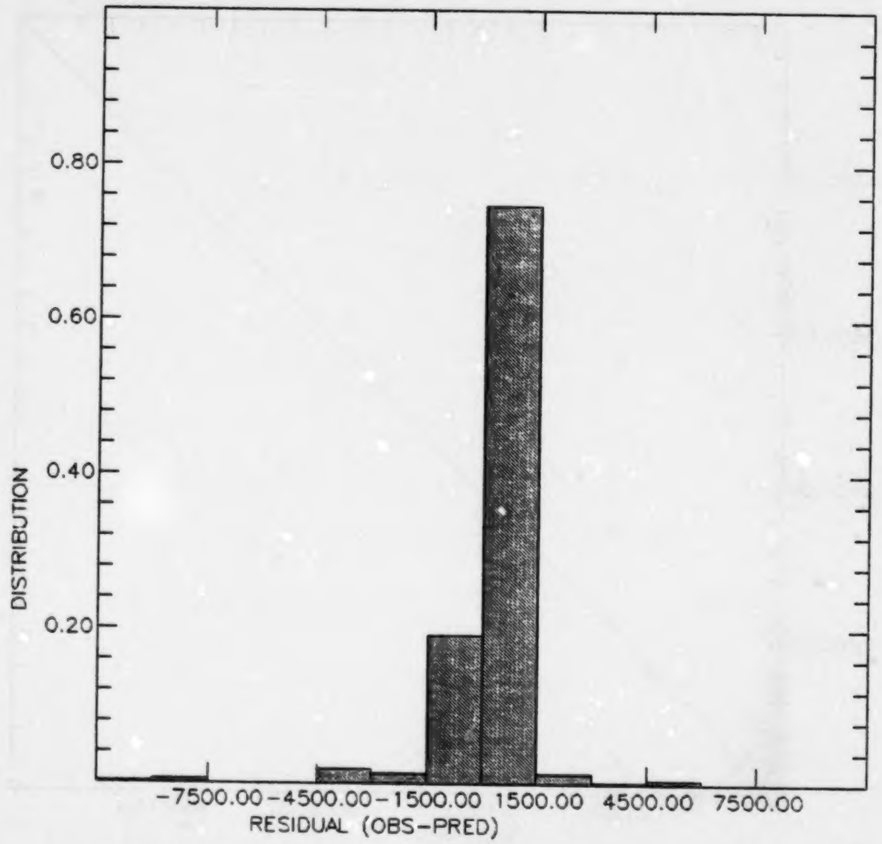


THE BINSIZE EQUALS 1500.000

```
RESIDUAL ANALYSIS

      AVERAGE          -113.60530
  STANDARD DEVIATION    1142.07300
      SKEWNESS           -3.30926
      KURTOSIS          29.54782
   OTHER MEASURES
       MEDIAN           0.00000
    UPPER QUARTILE        0.90000
    LOWER QUARTILE        0.00000
     MINIMUM VALUE       -10157.29000
     MAXIMUM VALUE        5895.49800
```

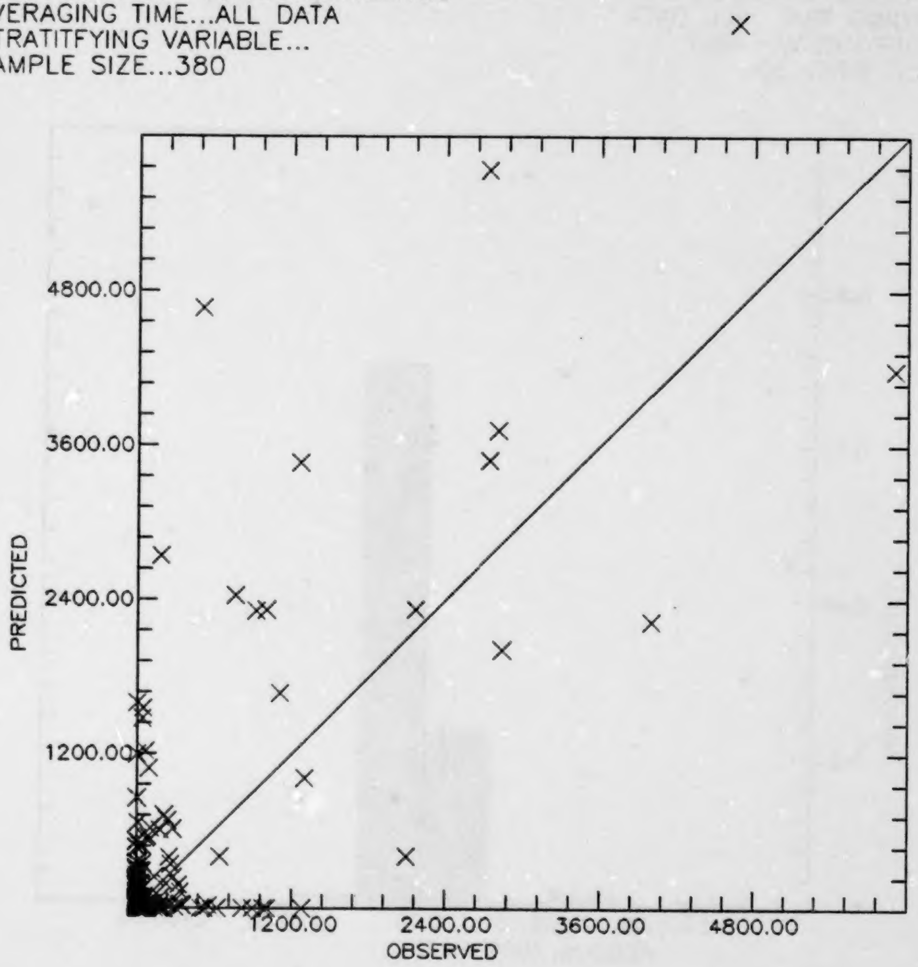
```
BIAS CONFIDENCE INTERVAL
AT THE 0.0500 LEVEL
LOWER BOUND -210.6108
UPPER BOUND -16.5999

STD RESIDUAL CONFIDENCE INTERVAL
AT THE 0.0500 LEVEL
LOWER BOUND 1162225.00
UPPER BOUND 1475969.00

THE MEASURES OF GROSS ERROR
THE ROOT MEAN SQUARE ERROR IS 1146.21
THE AVERAGE ABSOLUTE ERROR IS 350.44

VARIOUS MEASURES OF RELATIVE VARIABILITY
OBSERVATION COEFFICIENT OF VARIATION
                                3.9682
RESIDUAL COEFFICIENT OF VARIATION
                                7.9599
RATIO OF RESIDUAL TO OBSERVED ST. DEV.
                                2.0059
```

VARIABLE...TRACER
BEGINNING DATE...
ENDING DATE...
OBSERVATION SOURCE...TRACER DATA
OBSERVATION ANALYSIS...OKLAHOMA EXPERIMENTS
THE PREDICTION ALGORITHM...ARM3
AVERAGING TIME...ALL DATA
STRATITFYING VARIABLE...
SAMPLE SIZE...380



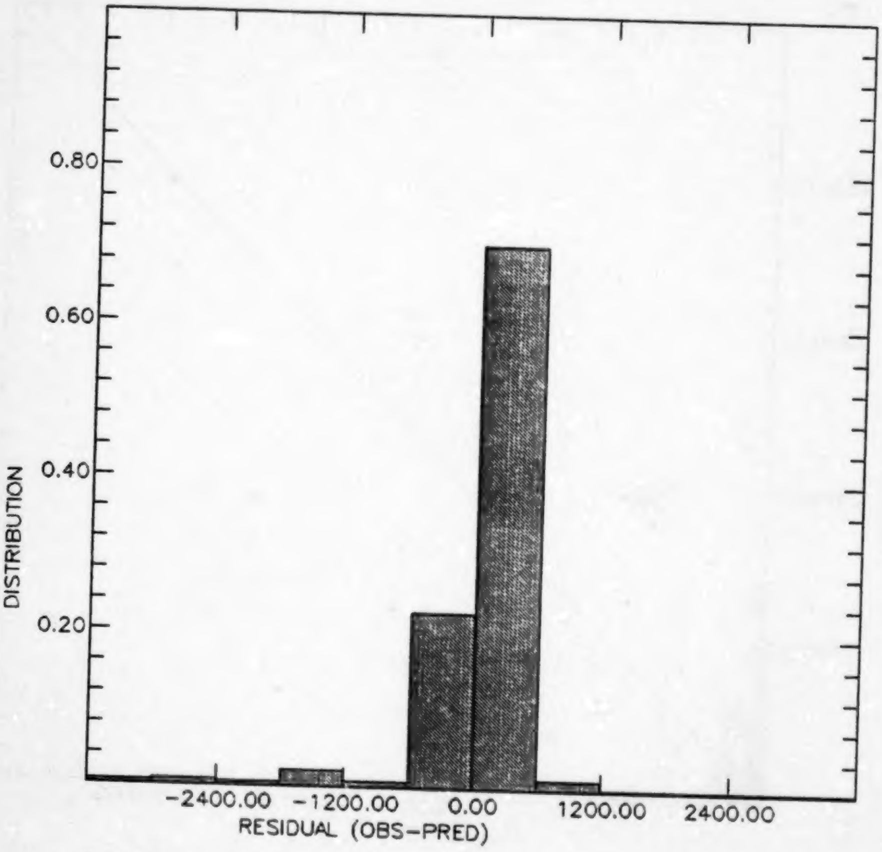
MOMENTS OF THE PROBABILITY DENSITY FUNCTION

	OBSERVED	PREDICTED
AVERAGE	143.47810	229.22170
STANDARD DEVIATION	569.34350	867.45600
SKEWNESS	6.28371	6.21785
KURTOSIS	46.41383	47.05829
OTHER MEASURES		
MEDIAN	0.00000	0.00000
UPPER QUARTILE	14.20000	23.40000
LOWER QUARTILE	0.00000	0.00000
MINIMUM VALUE	0.00000	0.00000
MAXIMUM VALUE	5896.99900	9284.79700

SKILL OF PREDICTION PARAMETERS

CORRELATION COEFFICIENT OF PREDICTED VERSUS OBSERVED 0.718
THE BOUNDS OF THE CORRELATION AT THE CONFIDENCE LEVEL OF 0.050 ARE
LOW BOUND 0.665 HIGH BOUND 0.763
RATIO OF OVER TO UNDER PREDICTIONS 2.220
PERCENT OF OVER PREDICTIONS GREATER THAN 200 PERCENT OF THE OBSERVED 22.105
PERCENT OF UNDER PREDICTIONS LESS THAN 50 PERCENT OF THE OBSERVED 28.158

VARIABLE...TRACER
BEGINNING DATE...
ENDING DATE...
OBSERVATION SOURCE...TRACER DATA
OBSERVATION ANALYSIS...OKLAHOMA EXPERIMENTS
THE PREDICTION ALGORITHM...MESOPUFF-1
AVERAGING TIME...ALL DATA
STRATITFYING VARIABLE...
SAMPLE SIZE...380



THE BINSIZE EQUALS 600.000

RESIDUAL ANALYSIS

AVERAGE	-68.36723
STANDARD DEVIATION	520.08050
SKEWNESS	-2.18300
KURTOSIS	19.85759
OTHER MEASURES	
MEDIAN	0.00000
UPPER QUARTILE	0.90000
LOWER QUARTILE	-5.50000
MINIMUM VALUE	-3578.09900
MAXIMUM VALUE	3003.79900

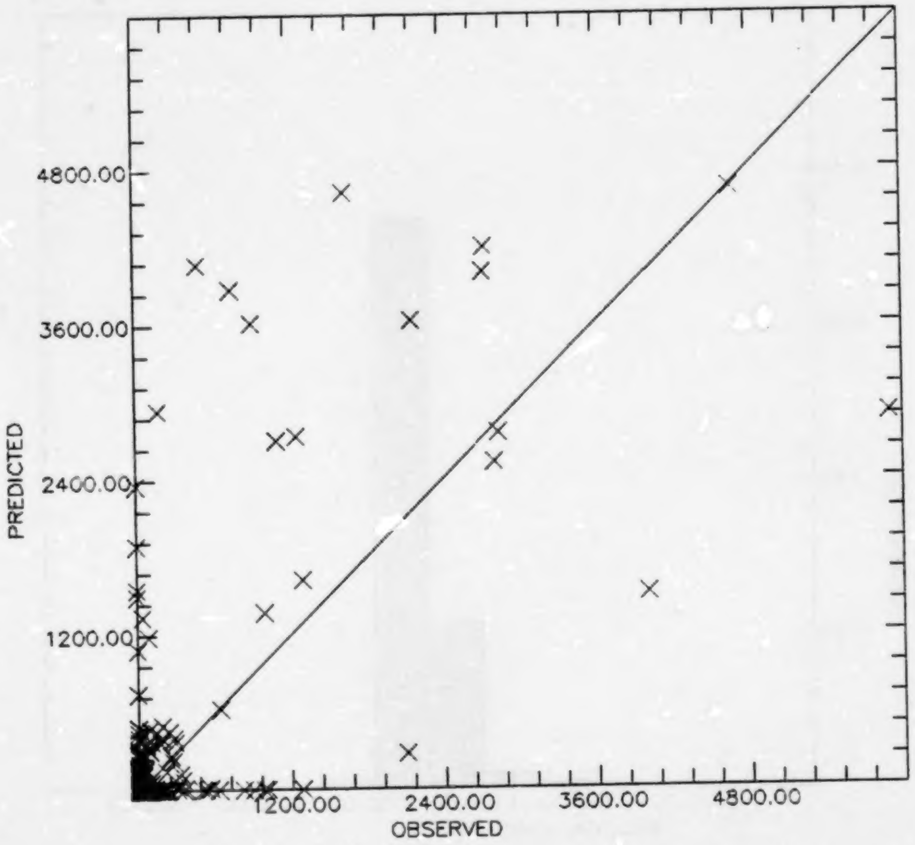
BIAS CONFIDENCE INTERVAL
AT THE 0.0500 LEVEL
LOWER BOUND -145.7006
UPPER BOUND 8.9662

STD RESIDUAL CONFIDENCE INTERVAL
AT THE 0.0500 LEVEL
LOWER BOUND 241014.3000
UPPER BOUND 306076.3000

THE MEASURES OF GROSS ERROR
THE ROOT MEAN SQUARE ERROR IS 523.88
THE AVERAGE ABSOLUTE ERROR IS 171.17

VARIOUS MEASURES OF RELATIVE VARIABILITY
OBSERVATION COEFFICIENT OF VARIATION
3.9682
RESIDUAL COEFFICIENT OF VARIATION
3.6248
RATIO OF RESIDUAL TO OBSERVED ST. DEV.
0.9135

VARIABLE...TRACER
BEGINNING DATE...
ENDING DATE...
OBSERVATION SOURCE...TRACER DATA
OBSERVATION ANALYSIS...OKLAHOMA EXPERIMENTS
THE PREDICTION ALGORITHM...MESOPUFF−1
AVERAGING TIME...ALL DATA
STRATITFYING VARIABLE...
SAMPLE SIZE...380



MOMENTS OF THE PROBABILITY DENSITY FUNCTION

	OBSERVED	PREDICTED
AVERAGE	143.47810	211.84340
STANDARD DEVIATION	569.34350	715.09600
SKEWNESS	6.28371	4.35133
KURTOSIS	46.41383	19.21700
OTHER MEASURES		
MEDIAN	0.00000	0.00000
UPPER QUARTILE	14.20000	19.90000
LOWER QUARTILE	0.00000	0.00000
MINIMUM VALUE	0.00000	0.00000
MAXIMUM VALUE	5896.99900	4646.09900

SKILL OF PREDICTION PARAMETERS
CORRELATION COEFFICIENT OF PREDICTED VERSUS OBSERVED 0.694
THE BOUNDS OF THE CORRELATION AT THE CONFIDENCE LEVEL OF 0.050 ARE
LOW BOUND 0.638 HIGH BOUND 0.743
RATIO OF OVER TO UNDER PREDICTIONS 2.167
PERCENT OF OVER PREDICTIONS GREATER THAN 200 PERCENT OF THE OBSERVED 24.474
PERCENT OF UNDER PREDICTIONS LESS THAN 50 PERCENT OF THE OBSERVED 29.211

```
VARIABLE...TRACER
BEGINNING DATE...
ENDING DATE...
OBSERVATION SOURCE...TRACER DATA
OBSERVATION ANALYSIS...OKLAHOMA EXPERIMENTS
THE PREDICTION ALGORITHM...ARM3
AVERAGING TIME...ALL DATA
STRATITFYING VARIABLE...
SAMPLE SIZE...380
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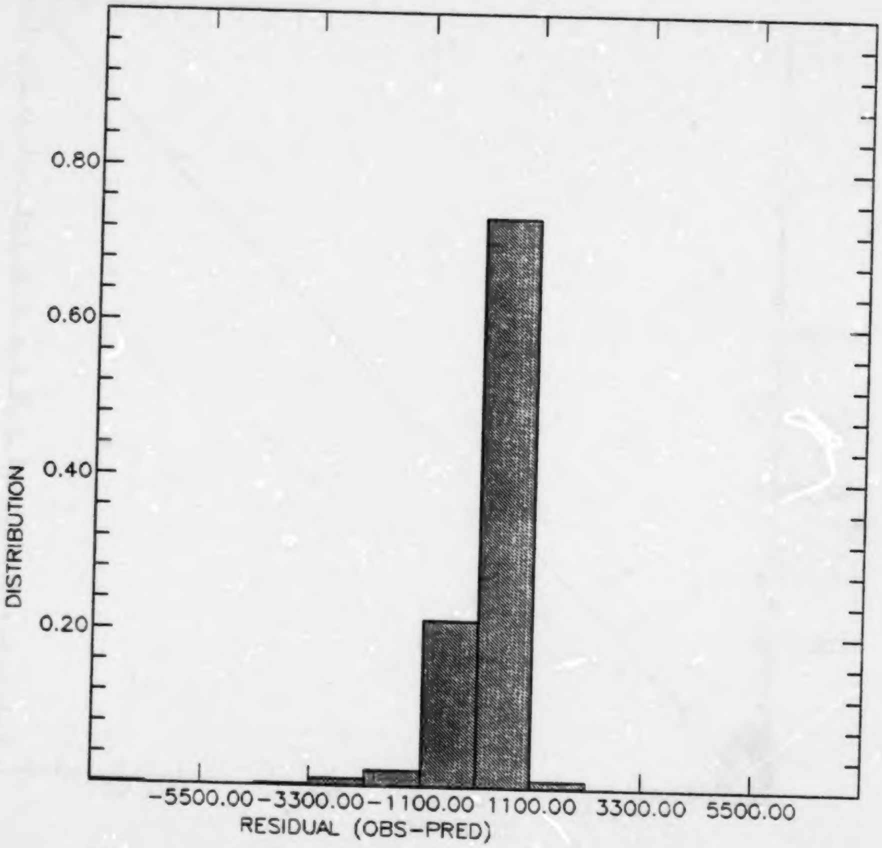
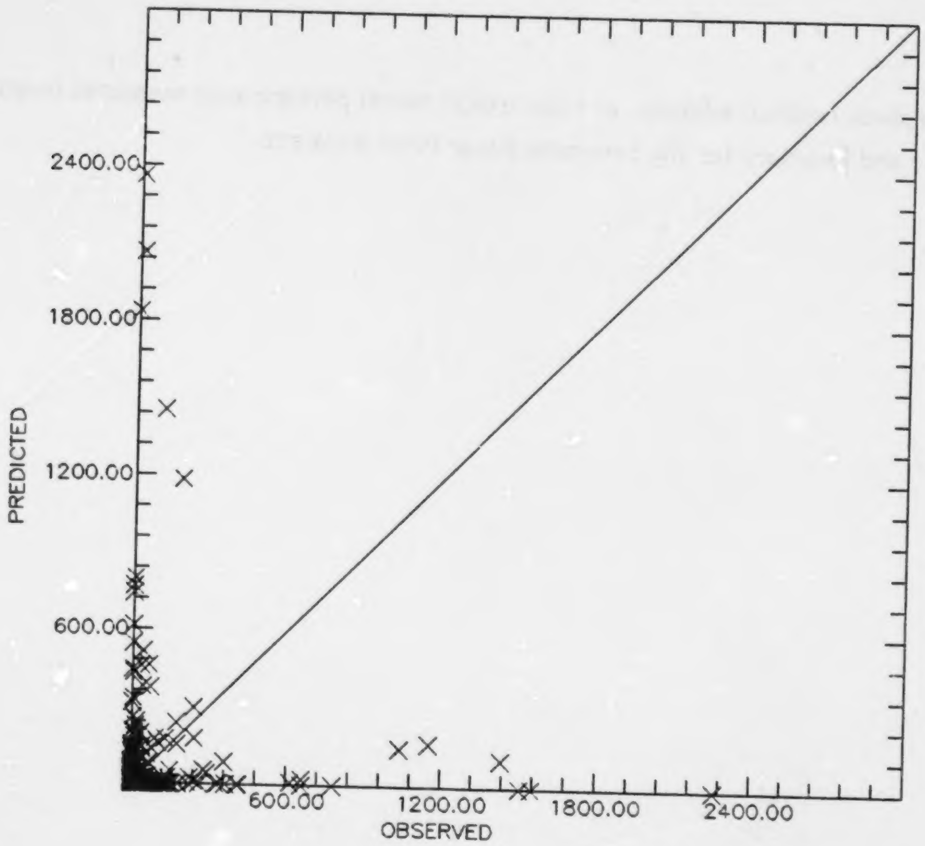


```
THE BINSIZE EQUALS  1100.000

RESIDUAL ANALYSIS
         AVERAGE          -85.74569
  STANDARD DEVIATION      606.33220
         SKEWNESS          -6.53932
         KURTOSIS          70.06320
  OTHER MEASURES
         MEDIAN             0.00000
     UPPER QUARTILE         0.60000
     LOWER QUARTILE        -0.20000
     MINIMUM VALUE      -7637.79800
     MAXIMUM VALUE       1765.10000

BIAS CONFIDENCE INTERVAL
AT THE 0.0500 LEVEL
LOWER BOUND -173.5314
UPPER BOUND 2.0400

STD RESIDUAL CONFIDENCE INTERVAL
AT THE 0.0500 LEVEL
LOWER BOUND 327584.2000
UPPER BOUND 416015.9000

THE MEASURES OF GROSS ERROR
THE ROOT MEAN SQUARE ERROR IS 611.57
THE AVERAGE ABSOLUTE ERROR IS 180.68

VARIOUS MEASURES OF RELATIVE VARIABILITY
OBSERVATION COEFFICIENT OF VARIATION
                              3.9682
RESIDUAL COEFFICIENT OF VARIATION
                              4.2260
RATIO OF RESIDUAL TO OBSERVED ST. DEV.
                              1.0650
```

Appendix E

Scatterplots, residual analysis, and statistical model performance measures (matched by time and location) for the Savannah River Plant data set.

VARIABLE...TRACER
BEGINNING DATE...
ENDING DATE...
OBSERVATION SOURCE...TRACER DATA
OBSERVATION ANALYSIS...SRP EXPERIMENTS
THE PREDICTION ALGORITHM...MESOPUFF2
AVERAGING TIME...ALL DATA
STRATITFYING VARIABLE...
SAMPLE SIZE...627

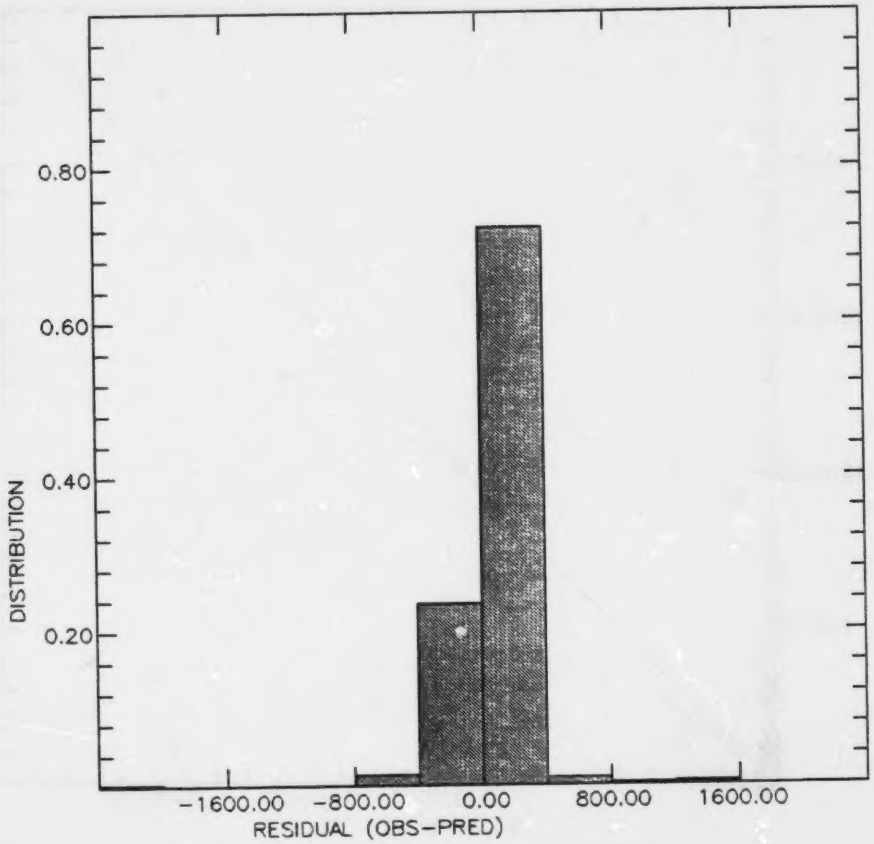


MOMENTS OF THE PROBABILITY DENSITY FUNCTION

	OBSERVED	PREDICTED
AVERAGE	35.06303	39.94327
STANDARD DEVIATION	166.19680	182.47840
SKEWNESS	8.45254	8.63677
KURTOSIS	84.48375	87.66593
OTHER MEASURES		
MEDIAN	0.00000	0.00000
UPPER QUARTILE	2.80000	7.00000
LOWER QUARTILE	0.00000	0.00000
MINIMUM VALUE	0.00000	0.00000
MAXIMUM VALUE	2259.59900	2359.59900

SKILL OF PREDICTION PARAMETERS
CORRELATION COEFFICIENT OF PREDICTED VERSUS OBSERVED 0.031
THE BOUNDS OF THE CORRELATION AT THE CONFIDENCE LEVEL OF 0.050 ARE
LOW BOUND −0.048 HIGH BOUND 0.109
RATIO OF OVER TO UNDER PREDICTIONS 2.483
PERCENT OF OVER PREDICTIONS GREATER THAN 200 PERCENT OF THE OBSERVED 23.445
PERCENT OF UNDER PREDICTIONS LESS THAN 50 PERCENT OF THE OBSERVED 27.113

VARIABLE...TRACER
BEGINNING DATE...
ENDING DATE...
OBSERVATION SOURCE...TRACER DATA
OBSERVATION ANALYSIS...SRP EXPERIMENTS
THE PREDICTION ALGORITHM...MESOPUFF2
AVERAGING TIME...ALL DATA
STRATITFYING VARIABLE...
SAMPLE SIZE...627



THE BINSIZE EQUALS 400.000

RESIDUAL ANALYSIS

AVERAGE	-4.88033
STANDARD DEVIATION	243.00160
SKEWNESS	-0.95206
KURTOSIS	46.31183
OTHER MEASURES	
MEDIAN	0.00000
UPPER QUARTILE	0.60000
LOWER QUARTILE	-0.70000
MINIMUM VALUE	-2349.99900
MAXIMUM VALUE	2259.59900

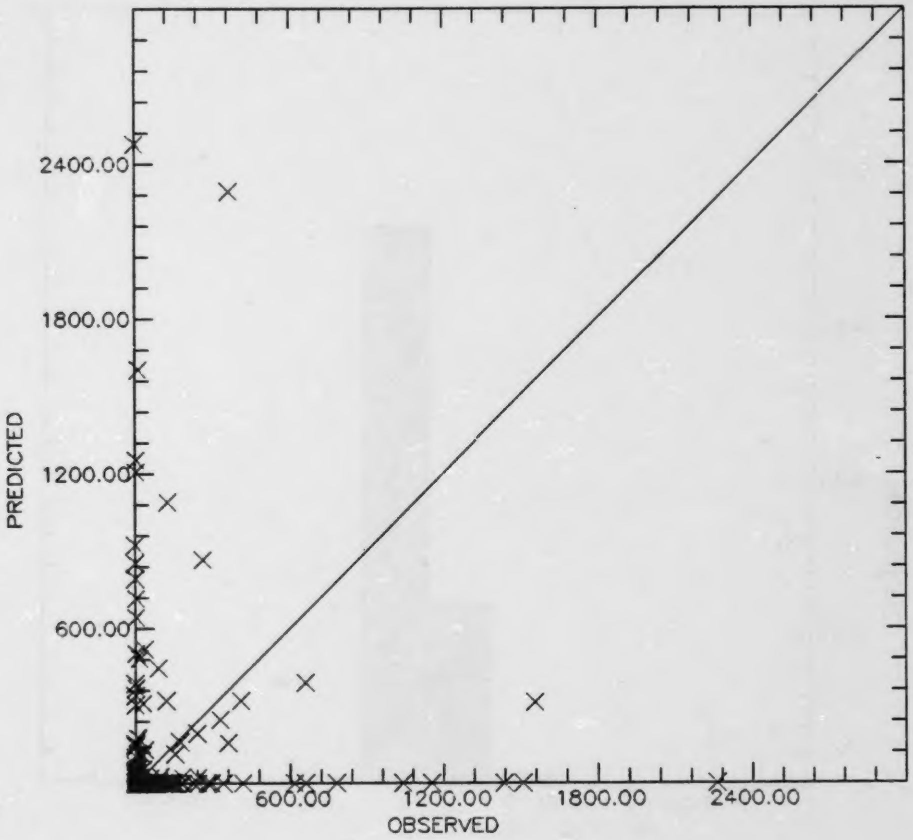
BIAS CONFIDENCE INTERVAL
AT THE 0.0500 LEVEL
LOWER BOUND -21.1212
UPPER BOUND 11.3605

STD RESIDUAL CONFIDENCE INTERVAL
AT THE 0.0500 LEVEL
LOWER BOUND 53941.7500
UPPER BOUND 64966.2300

THE MEASURES OF GROSS ERROR
THE ROOT MEAN SQUARE ERROR IS 242.86
THE AVERAGE ABSOLUTE ERROR IS 64.32

VARIOUS MEASURES OF RELATIVE VARIABILITY
OBSERVATION COEFFICIENT OF VARIATION
4.7399
RESIDUAL COEFFICIENT OF VARIATION
6.9304
RATIO OF RESIDUAL TO OBSERVED ST. DEV.
1.4621

VARIABLE...TRACER
BEGINNING DATE...
ENDING DATE...
OBSERVATION SOURCE...TRACER DATA
OBSERVATION ANALYSIS...SRP EXPERIMENTS
THE PREDICTION ALGORITHM...MESOPLUME
AVERAGING TIME...ALL DATA
STRATITFYING VARIABLE...
SAMPLE SIZE...627

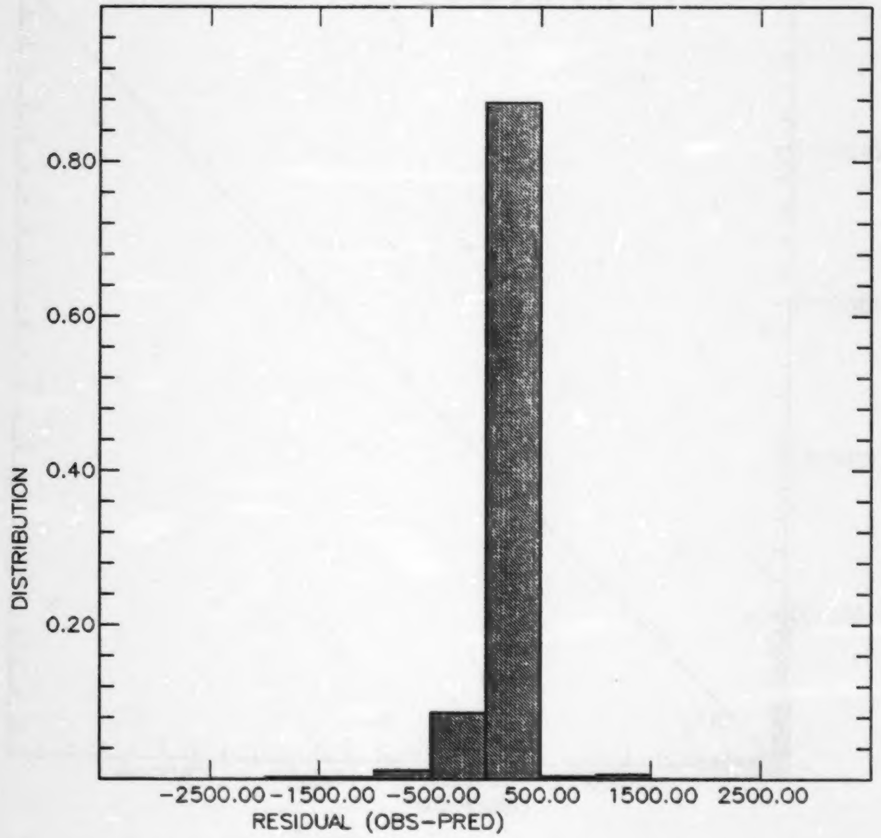


MOMENTS OF THE PROBABILITY DENSITY FUNCTION

	OBSERVED	PREDICTED
AVERAGE	35.06303	41.40114
STANDARD DEVIATION	166.19680	233.93650
SKEWNESS	8.45254	8.98199
KURTOSIS	84.48375	96.62515
OTHER MEASURES		
MEDIAN	0.00000	0.00000
UPPER QUARTILE	2.80000	0.00000
LOWER QUARTILE	0.00000	0.00000
MINIMUM VALUE	0.00000	0.00000
MAXIMUM VALUE	2259.59900	3298.49900

SKILL OF PREDICTION PARAMETERS
CORRELATION COEFFICIENT OF PREDICTED
VERSUS OBSERVED 0.082
THE BOUNDS OF THE CORRELATION AT THE
CONFIDENCE LEVEL OF 0.050 ARE
LOW BOUND 0.004 HIGH BOUND 0.160
RATIO OF OVER TO UNDER PREDICTIONS 1.623
PERCENT OF OVER PREDICTIONS
GREATER THAN 200 PERCENT OF THE
OBSERVED 9.410
PERCENT OF UNDER PREDICTIONS
LESS THAN 50 PERCENT OF THE
OBSERVED 36.683

VARIABLE...TRACER
BEGINNING DATE...
ENDING DATE...
OBSERVATION SOURCE...TRACER DATA
OBSERVATION ANALYSIS...SRP EXPERIMENTS
THE PREDICTION ALGORITHM...MESOPLUME
AVERAGING TIME...ALL DATA
STRATITFYING VARIABLE...
SAMPLE SIZE...627



THE BINSIZE EQUALS 500.000

RESIDUAL ANALYSIS

AVERAGE	-6.33804
STANDARD DEVIATION	275.58610
SKEWNESS	-3.16037
KURTOSIS	54.28928
OTHER MEASURES	
MEDIAN	0.00000
UPPER QUARTILE	1.70000
LOWER QUARTILE	0.00000
MINIMUM VALUE	-3169.09900
MAXIMUM VALUE	2259.59900

BIAS CONFIDENCE INTERVAL
AT THE 0.0500 LEVEL
LOWER BOUND -25.2204
UPPER BOUND 12.5443

STD RESIDUAL CONFIDENCE INTERVAL
AT THE 0.0500 LEVEL
LOWER BOUND 69377.9000
UPPER BOUND 83557.1600

THE MEASURES OF GROSS ERROR
THE ROOT MEAN SQUARE ERROR IS 275.44
THE AVERAGE ABSOLUTE ERROR IS 65.48

VARIOUS MEASURES OF RELATIVE VARIABILITY
OBSERVATION COEFFICIENT OF VARIATION
4.7399
RESIDUAL COEFFICIENT OF VARIATION
7.8597
RATIO OF RESIDUAL TO OBSERVED ST. DEV.
1.6582

```
VARIABLE...TRACER
BEGINNING DATE...
ENDING DATE...
OBSERVATION SOURCE...TRACER DATA
OBSERVATION ANALYSIS...SRP EXPERIMENTS
THE PREDICTION ALGORITHM...MSPUFF
AVERAGING TIME...ALL DATA
STRATITFYING VARIABLE...
SAMPLE SIZE...627
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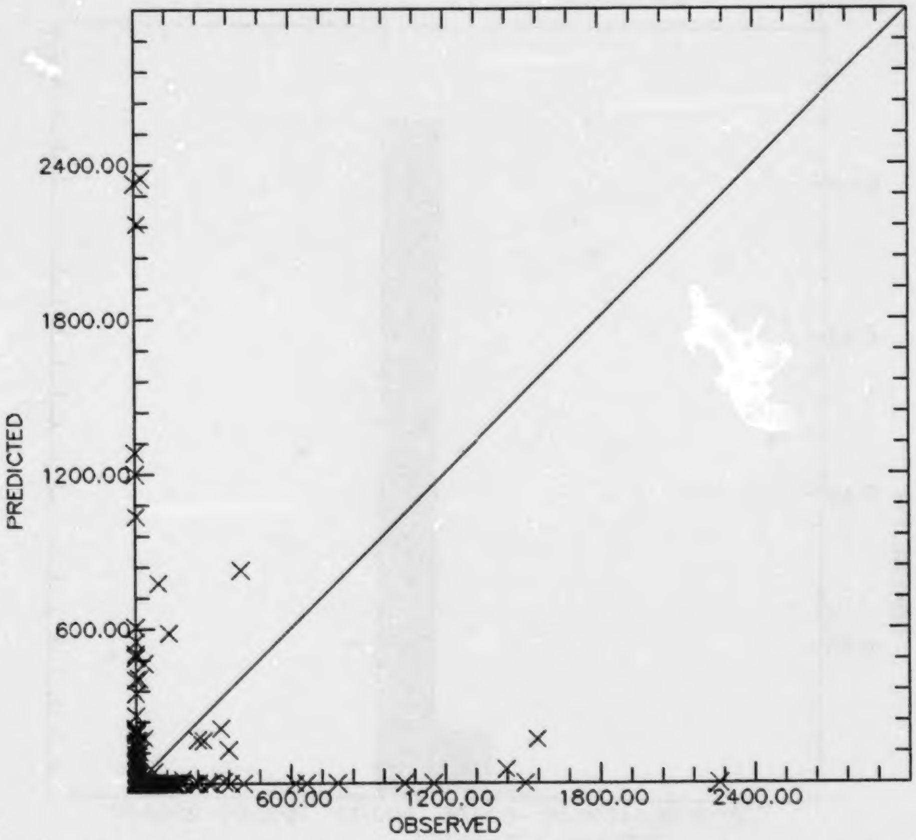
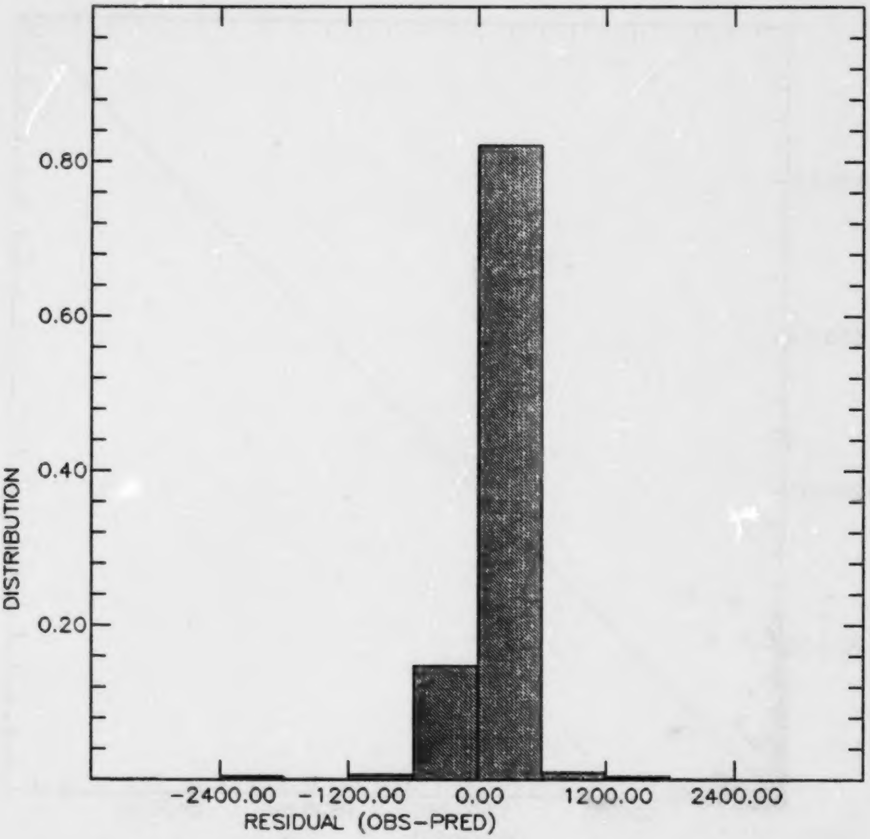


```
MOMENTS OF THE PROBABILITY DENSITY FUNCTION
                      OBSERVED        PREDICTED
          AVERAGE      35.06303        40.56700
 STANDARD DEVIATION   166.19680       239.38820
         SKEWNESS       8.45254         9.82962
         KURTOSIS      84.48375       113.44390
    OTHER MEASURES
           MEDIAN       0.00000         0.00000
   UPPER QUARTILE       2.80000         0.00000
   LOWER QUARTILE       0.00000         0.00000
    MINIMUM VALUE       0.00000         0.00000
    MAXIMUM VALUE    2259.59900      3581.59900
```

```
SKILL OF PREDICTION PARAMETERS
CORRELATION COEFFICIENT OF PREDICTED
VERSUS OBSERVED    0.012
THE BOUNDS OF THE CORRELATION AT THE
CONFIDENCE LEVEL OF 0.050 ARE
LOW BOUND -0.066 HIGH BOUND 0.090
RATIO OF OVER TO UNDER PREDICTIONS   1.668
PERCENT OF OVER PREDICTIONS
GREATER THAN 200 PERCENT OF THE
OBSERVED    15.630
PERCENT OF UNDER PREDICTIONS
LESS THAN 50 PERCENT OF THE
OBSERVED    36.045
```

VARIABLE...TRACER
BEGINNING DATE...
ENDING DATE...
OBSERVATION SOURCE...TRACER DATA
OBSERVATION ANALYSIS...SRP EXPERIMENTS
THE PREDICTION ALGORITHM...MSPUFF
AVERAGING TIME...ALL DATA
STRATITFYING VARIABLE...
SAMPLE SIZE...627



THE BINSIZE EQUALS 600.000

RESIDUAL ANALYSIS

AVERAGE	-5.50392
STANDARD DEVIATION	289.75150
SKEWNESS	-4.04830
KURTOSIS	62.80095
OTHER MEASURES	
MEDIAN	0.00000
UPPER QUARTILE	2.10000
LOWER QUARTILE	0.00000
MINIMUM VALUE	-3572.00000
MAXIMUM VALUE	2259.59900

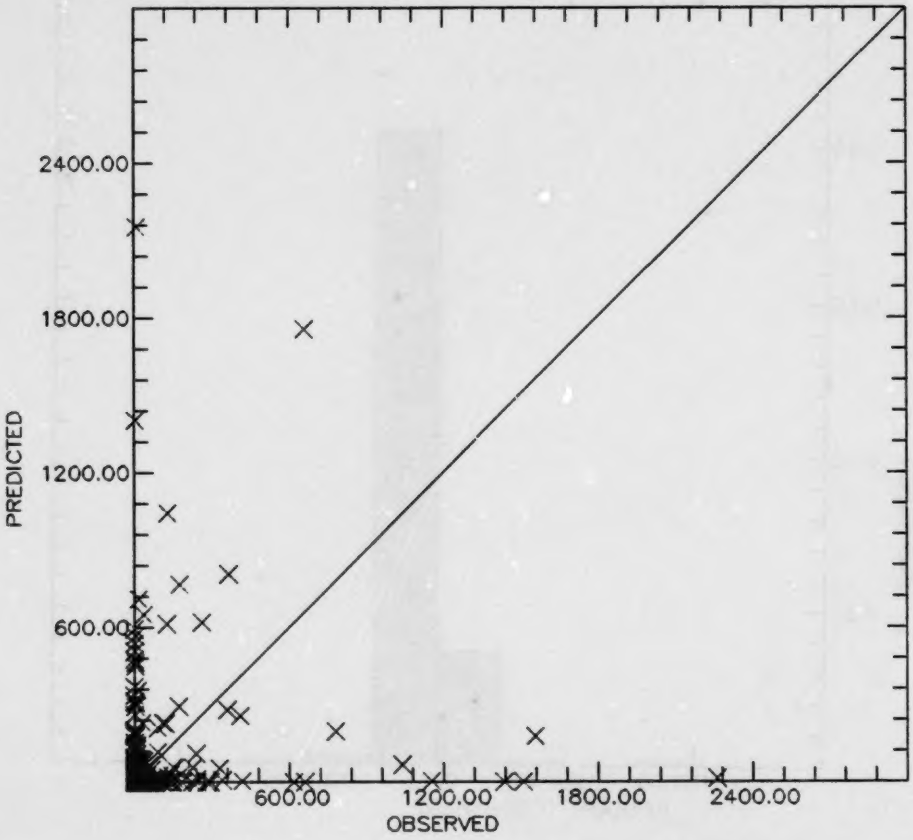
BIAS CONFIDENCE INTERVAL
AT THE 0.0500 LEVEL
LOWER BOUND -24.6798
UPPER BOUND 13.6720

STD RESIDUAL CONFIDENCE INTERVAL
AT THE 0.0500 LEVEL
LOWER BOUND 76693.3800
UPPER BOUND 92367.7800

THE MEASURES OF GROSS ERROR
THE ROOT MEAN SQUARE ERROR IS 289.57
THE AVERAGE ABSOLUTE ERROR IS 69.56

VARIOUS MEASURES OF RELATIVE VARIABILITY
OBSERVATION COEFFICIENT OF VARIATION
4.7399
RESIDUAL COEFFICIENT OF VARIATION
8.2637
RATIO OF RESIDUAL TO OBSERVED ST. DEV.
1.7434

VARIABLE...TRACER
BEGINNING DATE...
ENDING DATE...
OBSERVATION SOURCE...TRACER DATA
OBSERVATION ANALYSIS...SRP EXPERIMENTS
THE PREDICTION ALGORITHM...RTM2
AVERAGING TIME...ALL DATA
STRATITFYING VARIABLE...
SAMPLE SIZE...627



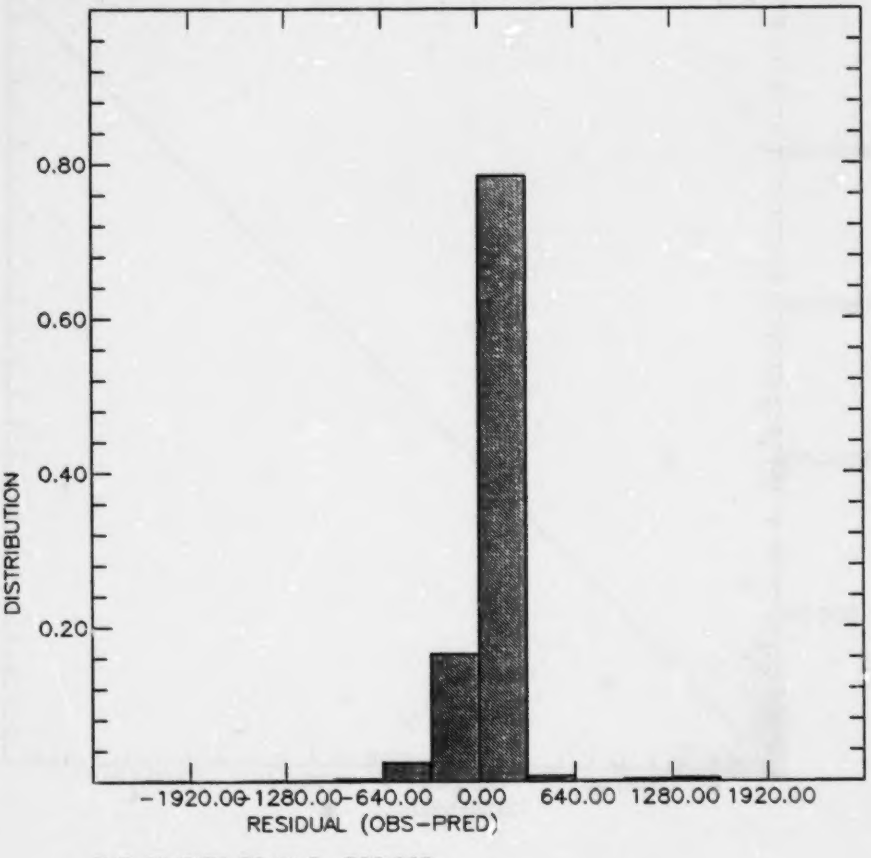
MOMENTS OF THE PROBABILITY DENSITY FUNCTION

	OBSERVED	PREDICTED
AVERAGE	35.06303	37.44487
STANDARD DEVIATION	166.19680	161.85610
SKEWNESS	8.45254	7.86348
KURTOSIS	84.48375	78.18749
OTHER MEASURES		
MEDIAN	0.00000	0.00000
UPPER QUARTILE	2.80000	1.00000
LOWER QUARTILE	0.00000	0.00000
MINIMUM VALUE	0.00000	0.00000
MAXIMUM VALUE	2259.59900	2153.49900

SKILL OF PREDICTION PARAMETERS

CORRELATION COEFFICIENT OF PREDICTED VERSUS OBSERVED 0.132
THE BOUNDS OF THE CORRELATION AT THE CONFIDENCE LEVEL OF 0.050 ARE
LOW BOUND 0.054 HIGH BOUND 0.208
RATIO OF OVER TO UNDER PREDICTIONS 2.029
PERCENT OF OVER PREDICTIONS GREATER THAN 200 PERCENT OF THE OBSERVED 17.703
PERCENT OF UNDER PREDICTIONS LESS THAN 50 PERCENT OF THE OBSERVED 30.941

VARIABLE...TRACER
BEGINNING DATE...
ENDING DATE...
OBSERVATION SOURCE...TRACER DATA
OBSERVATION ANALYSIS...SRP EXPERIMENTS
THE PREDICTION ALGORITHM...RTM2
AVERAGING TIME...ALL DATA
STRATITFYING VARIABLE...
SAMPLE SIZE...627



THE BINSIZE EQUALS 320.000

RESIDUAL ANALYSIS

AVERAGE	-2.38192
STANDARD DEVIATION	216.18610
SKEWNESS	1.11214
KURTOSIS	48.20900
OTHER MEASURES	
MEDIAN	0.00000
UPPER QUARTILE	1.10000
LOWER QUARTILE	0.00000
MINIMUM VALUE	-2143.89900
MAXIMUM VALUE	2246.79900

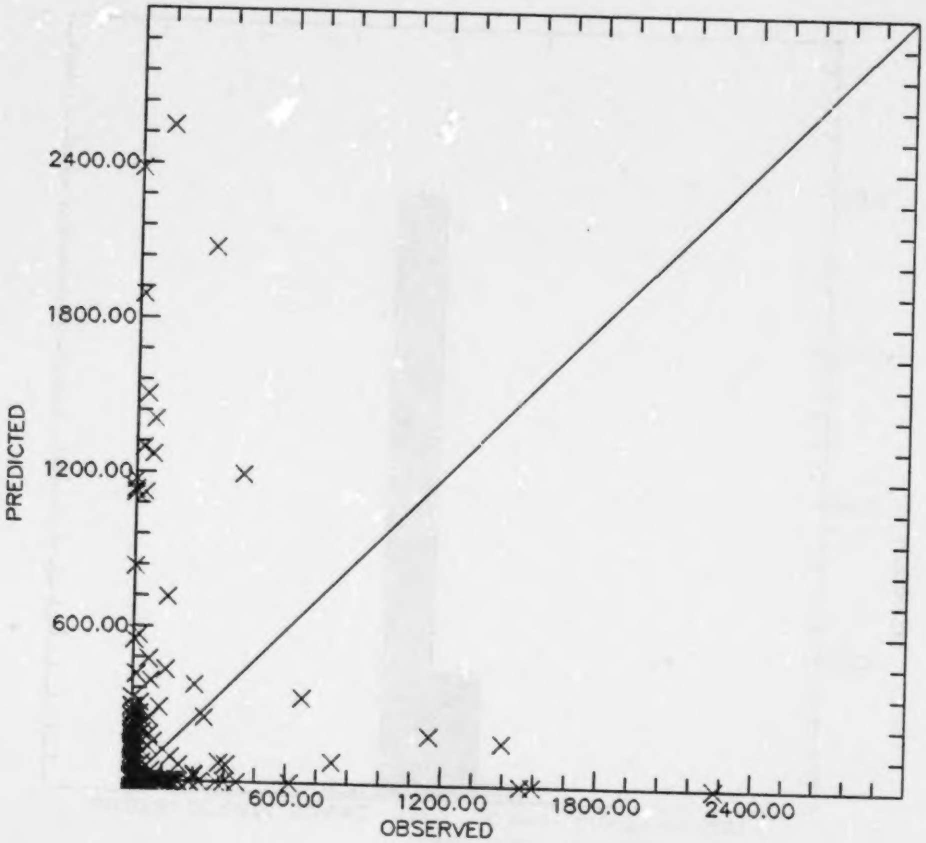
BIAS CONFIDENCE INTERVAL
AT THE 0.0500 LEVEL
LOWER BOUND -17.6469
UPPER BOUND 12.8831

STD RESIDUAL CONFIDENCE INTERVAL
AT THE 0.0500 LEVEL
LOWER BOUND 42693.5100
UPPER BOUND 51419.1200

THE MEASURES OF GROSS ERROR
THE ROOT MEAN SQUARE ERROR IS 216.03
THE AVERAGE ABSOLUTE ERROR IS 58.01

VARIOUS MEASURES OF RELATIVE VARIABILITY
OBSERVATION COEFFICIENT OF VARIATION
4.7399
RESIDUAL COEFFICIENT OF VARIATION
6.1656
RATIO OF RESIDUAL TO OBSERVED ST. DEV.
1.3008

VARIABLE...TRACER
BEGINNING DATE...
ENDING DATE...
OBSERVATION SOURCE...TRACER DATA
OBSERVATION ANALYSIS...SRP EXPERIMENTS
THE PREDICTION ALGORITHM...RADM
AVERAGING TIME...ALL DATA
STRATITFYING VARIABLE...
SAMPLE SIZE...627

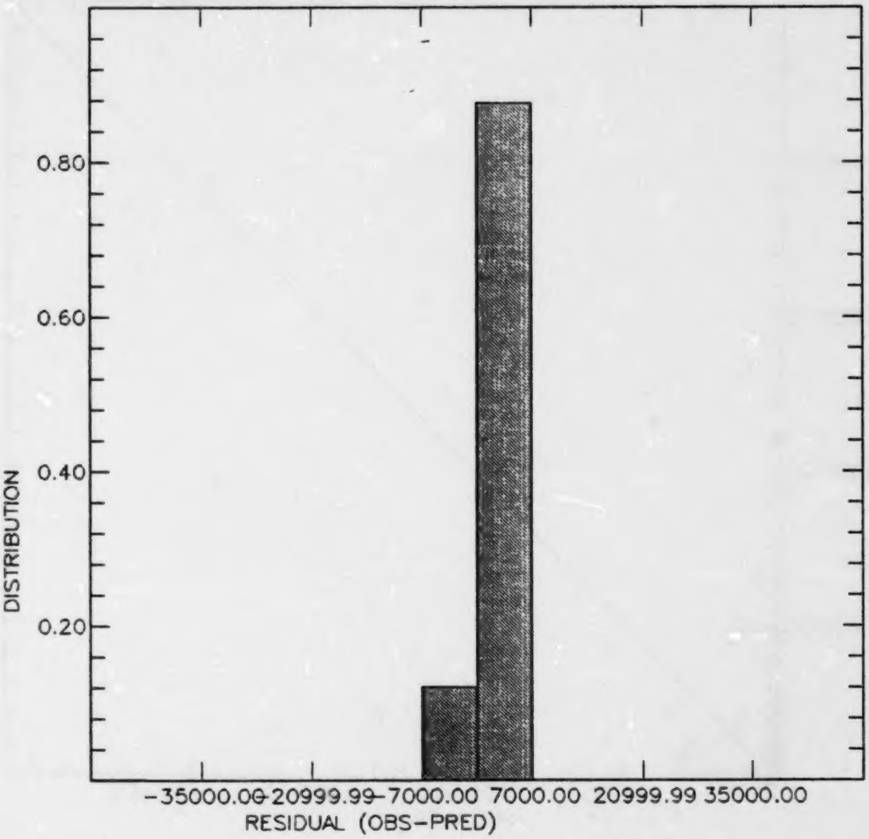


MOMENTS OF THE PROBABILITY DENSITY FUNCTION

	OBSERVED	PREDICTED
AVERAGE	35.06303	135.11670
STANDARD DEVIATION	166.19680	1874.31100
SKEWNESS	8.45254	23.99461
KURTOSIS	84.48375	588.35500
OTHER MEASURES		
MEDIAN	0.00000	0.00000
UPPER QUARTILE	2.80000	0.00000
LOWER QUARTILE	0.00000	0.00000
MINIMUM VALUE	0.00000	0.00000
MAXIMUM VALUE	2259.59900	46384.08000

SKILL OF PREDICTION PARAMETERS
CORRELATION COEFFICIENT OF PREDICTED VERSUS OBSERVED 0.264
THE BOUNDS OF THE CORRELATION AT THE CONFIDENCE LEVEL OF 0.050 ARE
LOW BOUND 0.189 HIGH BOUND 0.335
RATIO OF OVER TO UNDER PREDICTIONS 1.889
PERCENT OF OVER PREDICTIONS GREATER THAN 200 PERCENT OF THE OBSERVED 11.643
PERCENT OF UNDER PREDICTIONS LESS THAN 50 PERCENT OF THE OBSERVED 33.812

VARIABLE...TRACER
BEGINNING DATE...
ENDING DATE...
OBSERVATION SOURCE...TRACER DATA
OBSERVATION ANALYSIS...SRP EXPERIMENTS
THE PREDICTION ALGORITHM...RADM
AVERAGING TIME...ALL DATA
STRATITFYING VARIABLE...
SAMPLE SIZE...627



THE BINSIZE EQUALS 7000.000

RESIDUAL ANALYSIS

AVERAGE	−100.05480
STANDARD DEVIATION	1837.52000
SKEWNESS	−23.82716
KURTOSIS	583.26300
OTHER MEASURES	
MEDIAN	0.00000
UPPER QUARTILE	1.20000
LOWER QUARTILE	0.00000
MINIMUM VALUE	−45344.19000
MAXIMUM VALUE	2259.59900

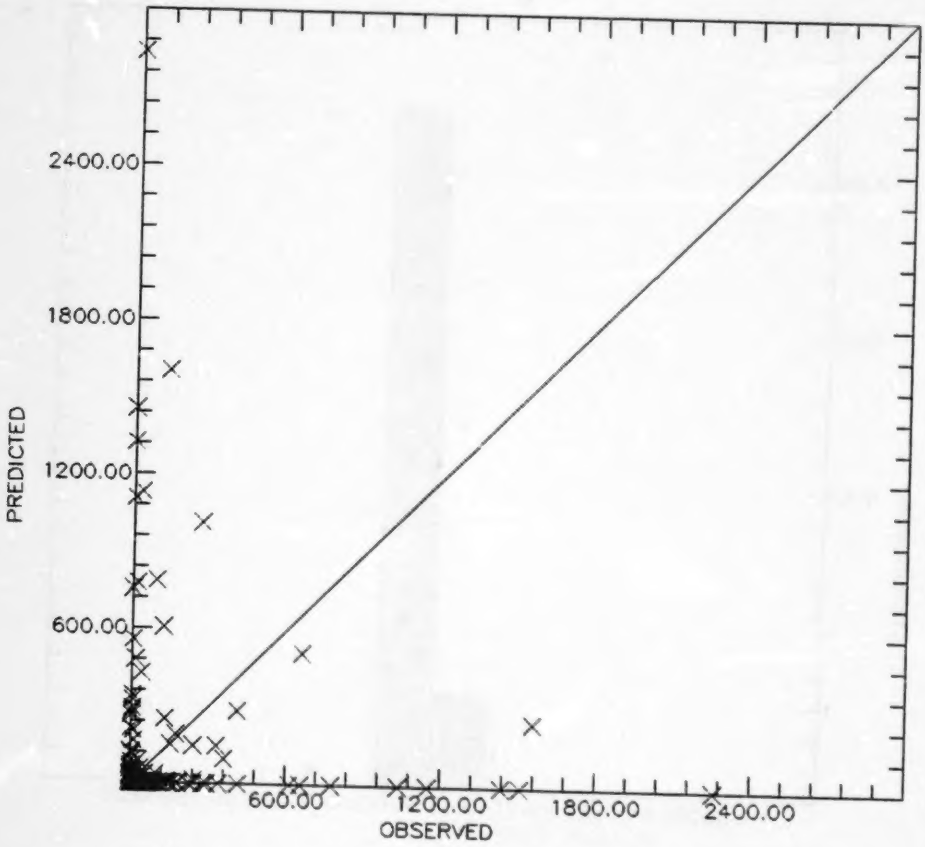
BIAS CONFIDENCE INTERVAL
AT THE 0.0500 LEVEL
LOWER BOUND −223.8696
UPPER BOUND 23.7600

STD RESIDUAL CONFIDENCE INTERVAL
AT THE 0.0500 LEVEL
LOWER BOUND 3084399.00
UPPER BOUND 3714780.00

THE MEASURES OF GROSS ERROR
THE ROOT MEAN SQUARE ERROR IS 1838.78
THE AVERAGE ABSOLUTE ERROR IS 151.94

VARIOUS MEASURES OF RELATIVE VARIABILITY
OBSERVATION COEFFICIENT OF VARIATION
4.7399
RESIDUAL COEFFICIENT OF VARIATION
52.4062
RATIO OF RESIDUAL TO OBSERVED ST. DEV.
11.0563

VARIABLE...TRACER
BEGINNING DATE...
ENDING DATE...
OBSERVATION SOURCE...TRACER DATA
OBSERVATION ANALYSIS...SRP EXPERIMENTS
THE PREDICTION ALGORITHM...MESOPUFF-1
AVERAGING TIME...ALL DATA
STRATITFYING VARIABLE...
SAMPLE SIZE...627



MOMENTS OF THE PROBABILITY DENSITY FUNCTION

	OBSERVED	PREDICTED
AVERAGE	35.06303	41.21975
STANDARD DEVIATION	166.19680	280.54060
SKEWNESS	8.45254	13.14785
KURTOSIS	84.48375	215.47160
OTHER MEASURES		
MEDIAN	0.00000	0.00000
UPPER QUARTILE	2.80000	0.00000
LOWER QUARTILE	0.00000	0.00000
MINIMUM VALUE	0.00000	0.00000
MAXIMUM VALUE	2259.59900	5308.79700

SKILL OF PREDICTION PARAMETERS

CORRELATION COEFFICIENT OF PREDICTED VERSUS OBSERVED 0.096

THE BOUNDS OF THE CORRELATION AT THE CONFIDENCE LEVEL OF 0.050 ARE LOW BOUND 0.018 HIGH BOUND 0.173

RATIO OF OVER TO UNDER PREDICTIONS 1.714

PERCENT OF OVER PREDICTIONS GREATER THAN 200 PERCENT OF THE OBSERVED 11.164

PERCENT OF UNDER PREDICTIONS LESS THAN 50 PERCENT OF THE OBSERVED 35.088

```
VARIABLE...TRACER
BEGINNING DATE...
ENDING DATE...
OBSERVATION SOURCE...TRACER DATA
OBSERVATION ANALYSIS...SRP EXPERIMENTS
THE PREDICTION ALGORITHM...MESOPUFF-1
AVERAGING TIME...ALL DATA
STRATITFYING VARIABLE...
SAMPLE SIZE...627
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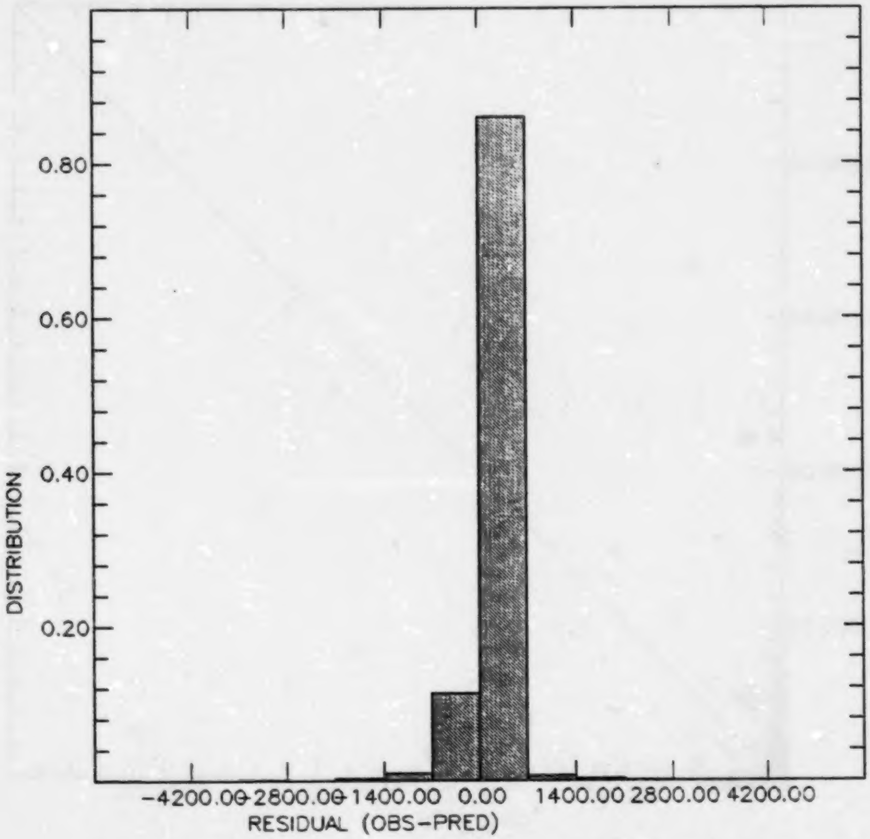


THE BINSIZE EQUALS 700.000

```
RESIDUAL ANALYSIS
        AVERAGE          -6.15670
   STANDARD DEVIATION   312.05870
        SKEWNESS         -6.91982
        KURTOSIS        117.62430
    OTHER MEASURES
         MEDIAN           0.00000
     UPPER QUARTILE       1.70000
     LOWER QUARTILE       0.00000
      MINIMUM VALUE   -4942.89900
      MAXIMUM VALUE    2259.59900
```

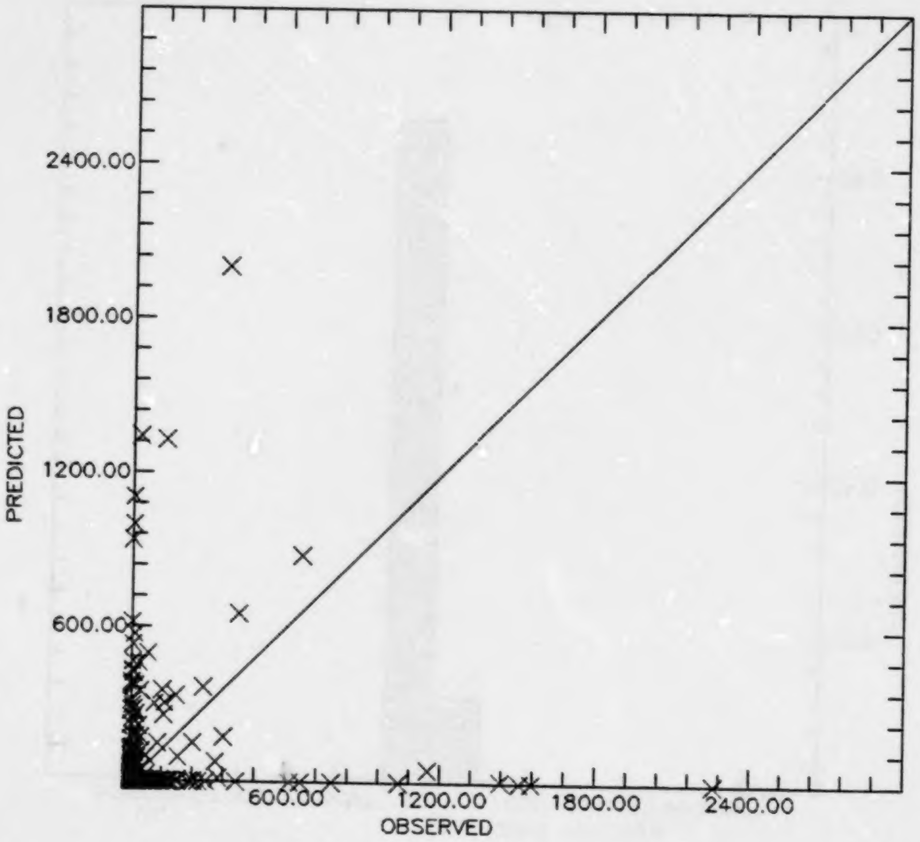
```
BIAS CONFIDENCE INTERVAL
AT THE 0.0500 LEVEL
LOWER BOUND -27.6126
UPPER BOUND 15.2992

STD RESIDUAL CONFIDENCE INTERVAL
AT THE 0.0500 LEVEL
LOWER BOUND 88956.7700
UPPER BOUND 107137.5000

THE MEASURES OF GROSS ERROR
THE ROOT MEAN SQUARE ERROR IS 311.87
THE AVERAGE ABSOLUTE ERROR IS 65.81

VARIOUS MEASURES OF RELATIVE VARIABILITY
OBSERVATION COEFFICIENT OF VARIATION
                                 4.7399
RESIDUAL COEFFICIENT OF VARIATION
                                 8.8999
RATIO OF RESIDUAL TO OBSERVED ST. DEV.
                                 1.8776
```

VARIABLE...TRACER
BEGINNING DATE...
ENDING DATE...
OBSERVATION SOURCE...TRACER DATA
OBSERVATION ANALYSIS...SRP EXPERIMENTS
THE PREDICTION ALGORITHM...ARM3
AVERAGING TIME...ALL DATA
STRATITFYING VARIABLE...
SAMPLE SIZE...627



MOMENTS OF THE PROBABILITY DENSITY FUNCTION

	OBSERVED	PREDICTED
AVERAGE	35.06303	37.38574
STANDARD DEVIATION	166.19680	155.94400
SKEWNESS	8.45254	7.05794
KURTOSIS	84.48375	62.90242
OTHER MEASURES		
MEDIAN	0.00000	0.00000
UPPER QUARTILE	2.80000	0.00000
LOWER QUARTILE	0.00000	0.00000
MINIMUM VALUE	0.00000	0.00000
MAXIMUM VALUE	2259.59900	1999.69900

SKILL OF PREDICTION PARAMETERS
CORRELATION COEFFICIENT OF PREDICTED VERSUS OBSERVED 0.101
THE BOUNDS OF THE CORRELATION AT THE CONFIDENCE LEVEL OF 0.050 ARE
LOW BOUND 0.022 HIGH BOUND 0.178
RATIO OF OVER TO UNDER PREDICTIONS 2.215
PERCENT OF OVER PREDICTIONS GREATER THAN 200 PERCENT OF THE OBSERVED 17.703
PERCENT OF UNDER PREDICTIONS LESS THAN 50 PERCENT OF THE OBSERVED 30.303

```
VARIABLE...TRACER
BEGINNING DATE...
ENDING DATE...
OBSERVATION SOURCE...TRACER DATA
OBSERVATION ANALYSIS...SRP EXPERIMENTS
THE PREDICTION ALGORITHM...ARM3
AVERAGING TIME...ALL DATA
STRATITFYING VARIABLE...
SAMPLE SIZE...627
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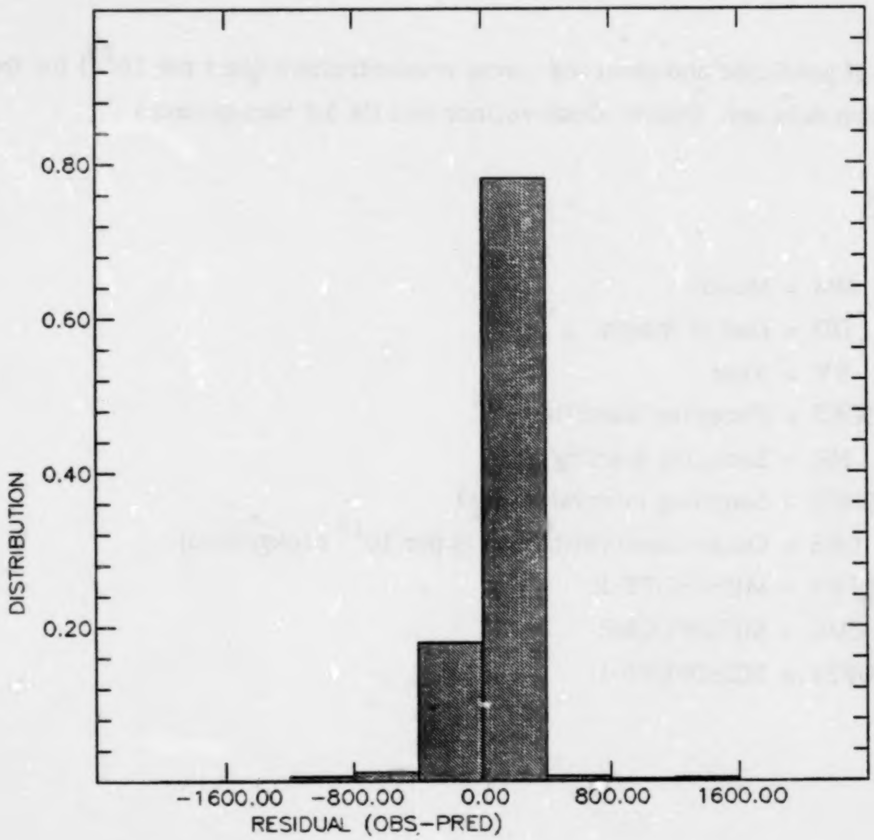

```
THE BINSIZE EQUALS  400.000
```

```
RESIDUAL ANALYSIS

        AVERAGE         -2.32271
  STANDARD DEVIATION   216.15710
        SKEWNESS         2.00752
        KURTOSIS        41.46015
    OTHER MEASURES
         MEDIAN          0.00000
     UPPER QUARTILE      0.90000
     LOWER QUARTILE      0.00000
      MINIMUM VALUE  -1633.79900
      MAXIMUM VALUE   2259.59900
```

```
BIAS CONFIDENCE INTERVAL
AT THE 0.0500 LEVEL
LOWER BOUND -17.3189
UPPER BOUND 12.6735

STD RESIDUAL CONFIDENCE INTERVAL
AT THE 0.0500 LEVEL
LOWER BOUND 42682.0700
UPPER BOUND 51405.3300

THE MEASURES OF GROSS ERROR
THE ROOT MEAN SQUARE ERROR IS 216.00
THE AVERAGE ABSOLUTE ERROR IS 59.98

VARIOUS MEASURES OF RELATIVE VARIABILITY
OBSERVATION COEFFICIENT OF VARIATION
                                  4.7399
RESIDUAL COEFFICIENT OF VARIATION
                                  6.1648
RATIO OF RESIDUAL TO OBSERVED ST. DEV.
                                  1.3006
```

Appendix F

Tables of predicted and observed tracer concentrations (part per 10^{15}) for the Oklahoma data set. (Note: Observations include 3.0 background.)

Legend

MM = Month
DD = Day of month
YY = Year
RECEP = Receptor identifier
HR = Sampling starting time
SHRS = Sampling interval (hours)
OBS = Observation (with 3 parts per 10^{15} background)
PUFF2 = MESOPUFF-II
PLUME = MESOPLUME
PUFF1 = MESOPUFF-I

```
DD MM YY  RECEP   HR  SHRS      OBS     PUFF2     PLUME    MSPUFF      RTM2      RADM      ****     ARRPA     PUFF1      ARM3
  9
 8  7 80 190112 2100 0.75       3.1       0.0     323.5     403.8       0.0       0.0       0.0       0.0      90.3       0.0
 8  7 80 190113 2100 0.75       4.0       0.0     922.6    2114.1       0.0       0.0       0.0       0.0     408.3       0.0
 8  7 80 190114 2100 0.75       4.7       0.0    2793.2    5701.7       0.0       0.0       0.0       0.0    1554.7       0.0
 8  7 80 190115 2100 0.75       4.9       0.0    4846.5    2853.7       0.0       0.0       0.0       0.0    2361.5       0.0
 8  7 80 190116 2100 0.75       3.0       0.0    5136.4     719.0       0.0       0.0       0.0       0.0    1892.0       0.0
 8  7 80 190118 2100 0.75       3.0       0.0    2453.6       0.0       0.0       0.0       0.0       0.0     378.6       0.0
 8  7 80 190119 2100 0.75       3.0       0.0     809.4       0.0       0.0       0.0       0.0       0.0      32.1       0.0
 8  7 80 190120 2100 0.75       3.7       0.0     144.3       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 8  7 80 190122 2100 0.75       5.7      11.4       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
10
 8  7 80 190112 2145 0.75     650.0       0.0     756.8    6553.6      26.2       0.0       0.0       0.0     624.7     399.0
 8  7 80 190113 2145 0.75    1300.0       0.0    1782.9   12667.7     368.5       0.0       0.0       0.0    1629.4    1010.5
 8  7 80 190114 2145 0.75     920.0       0.0    3975.5   11333.9     324.0       0.0       0.0       0.0    3622.8    2310.5
 8  7 80 190115 2145 0.75     760.0       0.0    5031.2    2937.3     253.3      37.7       0.0       0.3    3881.2    2433.6
 8  7 80 190116 2145 0.75    1110.0       0.0    4341.1     547.5     202.8     308.2       0.0       3.5    2705.5    1675.9
 8  7 80 190118 2145 0.75     290.0     121.1    1411.6       0.0     281.7    1851.0       0.0       0.0     375.5     238.3
 8  7 80 190119 2145 0.75     130.0     322.2     380.8       0.0     355.7    1419.0       0.0       0.0      23.0      14.2
 8  7 80 190120 2145 0.75      16.0     533.3      48.1       0.0     388.6    1103.9       0.0       0.0       0.0       0.0
 8  7 80 190121 2145 0.75      27.1     468.7       0.0       0.0      41.4     857.3       0.0       0.0       0.0       0.0
 8  7 80 190122 2145 0.75       5.7    1937.6       0.0       0.0      34.7    3417.9       0.0    3515.3       0.0       0.0
10
 8  7 80 190112 2230 0.75    4000.0       0.0    1451.7   13179.3      69.0       0.0       0.0       0.1    1514.0    2231.9
 8  7 80 190113 2230 0.75    5900.0       0.0    2859.5   16899.1     622.5       0.0       0.0       1.5    2893.2    4188.0
 8  7 80 190114 2230 0.75    4670.0       0.0    6648.8   10296.8     561.4       0.0       0.0      18.3    4646.1    6878.8
 8  7 80 190115 2230 0.75    2730.0       0.0    4787.4    1996.7     464.4      37.7       0.0      93.9    4006.8    5739.7
 8  7 80 190116 2230 0.75    2810.0       0.0    3538.7     307.8     395.1     370.3       0.0     316.7    2533.6    3722.9
 8  7 80 190118 2230 0.75    2100.0     234.1     645.5       0.0     536.8    3419.2       0.0    1229.9     276.0     409.6
 8  7 80 190119 2230 0.75     560.0     800.7     111.0       0.0     626.2    4563.4       0.0    1502.4      12.3      17.5
 8  7 80 190120 2230 0.75     215.0    1682.2       0.0       0.0     662.8    5159.5       0.0    1463.3       0.0       0.0
 8  7 80 190121 2230 0.75       3.6    1825.1       0.0       0.0     139.9    4604.4       0.0    1345.7       0.0       0.0
 8  7 80 190122 2230 0.75       4.1    3274.6       0.0       0.0     134.6    7711.1       0.0    3926.7       0.0       0.0
10
 8  7 80 190112 2315 0.75    2840.0       0.0    2408.4   20280.8     128.5       0.0       0.0       0.3    2758.3    2015.8
 8  7 80 190113 2315 0.75    2740.0       0.0    4152.2   14808.4     762.0       0.0       0.0       4.4    4199.5    3487.7
 8  7 80 190114 2315 0.75    1650.0       0.0   10813.3    2590.4     712.4       0.0       0.0      54.9    4624.5    9284.8
 8  7 80 190115 2315 0.75    1260.0       0.0    4115.2      32.0     633.3       0.0       0.0     280.7    2738.2    3468.1
 8  7 80 190116 2315 0.75    1000.0       0.0    2729.1       0.0     576.9     186.4       0.0     939.7    1376.2    2320.4
 8  7 80 190118 2315 0.75     340.0     339.0     155.0       0.0     765.3    4704.6       0.0    3689.7      79.9     129.7
 8  7 80 190119 2315 0.75      50.0    1435.5       0.0       0.0     811.5    9433.4       0.0    4507.2       0.0       0.0
 8  7 80 190120 2315 0.75      14.0    3446.7       0.0       0.0     822.5   12167.0       0.0    4389.9       0.0       0.0
 8  7 80 190121 2315 0.75       2.8    4069.0       0.0       0.0     295.6   11241.3       0.0    4037.1       0.0       0.0
 8  7 80 190122 2315 0.75       3.4    4022.3       0.0       0.0     299.5   12879.5       0.0    1234.3       0.0       0.0
10
 9  7 80 191112    0 0.75    2170.0       0.0     418.5   11175.7     468.0       0.0       0.0     979.6    3631.1    2325.6
 9  7 80 191113    0 0.75     500.0       0.0     815.7    4545.5    1566.0       0.0       0.0    3207.3    4075.1    4664.2
 9  7 80 191114    0 0.75     182.0       0.0     490.2     234.1    1543.8       0.0       0.0    8114.7    2939.9    2740.0
 9  7 80 191115    0 0.75      88.0       4.4       0.0       0.0    1450.9       0.0       0.0   10242.3    1188.9       0.0
 9  7 80 191116    0 0.75      90.0      75.6       0.0       0.0    1359.2      59.9       0.0    7598.0     473.4       0.0
 9  7 80 191118    0 0.75       3.0    1639.8       0.0       0.0    1419.9    2690.8       0.0    2300.7       0.0       0.0
 9  7 80 191119    0 0.75       3.0    2881.8       0.0       0.0    1530.2    5460.4       0.0    1208.8       0.0       0.0
 9  7 80 191120    0 0.75       3.8    3642.2       0.0       0.0    1535.6    7606.8       0.0     503.5       0.0       0.0
 9  7 80 191121    0 0.75       2.7    3243.6       0.0       0.0     650.0    8027.3       0.0     230.8       0.0       0.0
 9  7 80 191122    0 0.75       3.8    1160.8       0.0       0.0     589.3    5260.7       0.0       2.9       0.0       0.0
```

```
DD MM YY RECEP   HR  SHRS    OBS   PUFF2   PLUME  MSPUFF    RTM2    RADM    ****   ARRPA   PUFF1    ARM3
10
 9  7 80 191112   45 0.75   43.0     0.0   139.5  3726.0   648.5     0.0     0.0   746.4  1338.3  1471.0
 9  7 80 191113   45 0.75    4.0     5.9   271.9  1515.2  1402.3     0.0     0.0  1127.0  1498.2  1591.4
 9  7 80 191114   45 0.75    4.0   114.6   163.4    78.0  1390.3    43.7     0.0  2960.3  1084.8  1193.4
 9  7 80 191115   45 0.75    4.5   643.9     0.0     0.0  1348.4   282.4     0.0  3638.6   443.9   469.4
 9  7 80 191116   45 0.75    9.0  1299.1     0.0     0.0  1308.5   899.2     0.0  2615.9   175.1   188.5
 9  7 80 191118   45 0.75    3.0  2891.0     0.0     0.0  1324.4  4502.4     0.0   767.9     0.0     0.0
 9  7 80 191119   45 0.75    1.0  2734.2     0.0     0.0  1374.3  5998.9     0.0   403.0     0.0     0.0
 9  7 80 191120   45 0.75    4.5  2128.6     0.0     0.0  1382.5  5953.8     0.0   168.2     0.0     0.0
 9  7 80 191121   45 0.75    3.1  1578.4     0.0     0.0   695.1  4581.3     0.0    77.0     0.0     0.0
 9  7 80 191122   45 0.75    3.7   413.8     0.0     0.0   704.6  1843.2     0.0     0.9     0.0     0.0
 9
 9  7 80 191112  130 0.75    4.6    58.6     0.0     0.8   715.0   474.9     0.0   419.9   127.9   854.9
 9  7 80 191114  130 0.75    5.0   925.2     0.0     0.0  1186.6  2075.6     0.0   255.4   104.8   520.0
 9  7 80 191115  130 0.75    4.8  1639.8     0.0     0.0  1174.1  2751.6     0.0   224.5    47.6   464.9
 9  7 80 191116  130 0.75    3.0  2078.9     0.0     0.0  1164.8  2877.6     0.0    83.3    17.3   172.4
 9  7 80 191118  130 0.75    3.0  2494.9     0.0     0.0  1156.7  4321.4     0.0     1.1     0.0     2.3
 9  7 80 191119  130 0.75    3.0  1831.6     0.0     0.0  1170.2  4502.3     0.0     0.1     0.0     0.2
 9  7 80 191120  130 0.75    4.1   926.1     0.0     0.0  1180.9  3514.1     0.0     0.3     0.0     0.6
 9  7 80 191121  130 0.75    2.9   501.5     0.0     0.0   661.2  1942.0     0.0     0.1     0.0     0.2
 9  7 80 191122  130 0.75    5.5    26.9     0.0     0.0   727.3    89.6     0.0     0.0     0.0     0.0
32
 9  7 80 191600  800 3.00    2.8     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 9  7 80 191601  800 3.00    2.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 9  7 80 191602  800 3.00    3.6     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 9  7 80 191603  800 3.00    3.7     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 9  7 80 191604  800 3.00    2.6     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 9  7 80 191606  800 3.00   17.2     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 9  7 80 191607  800 3.00    3.2     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 9  7 80 191609  800 3.00  627.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 9  7 80 191610  800 3.00 1280.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 9  7 80 191611  800 3.00 1010.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 9  7 80 191612  800 3.00  900.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 9  7 80 191613  800 3.00  980.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 9  7 80 191615  800 3.00   16.0     0.0     0.0     0.0     0.0     0.0     0.0     9.6     0.4    12.0
 9  7 80 191616  800 3.00    4.8     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.1     3.0
 9  7 80 191617  800 3.00    2.5     0.0     0.0     0.1     0.0     0.0     0.0     0.0     0.5    14.9
 9  7 80 191618  800 3.00    2.4     0.0     0.0     5.2     0.0     0.0     0.0     0.0     3.2    96.7
 9  7 80 191619  800 3.00    2.6     0.0     0.0   150.2     0.0     0.0     0.0     0.0     0.2     6.0
 9  7 80 191620  800 3.00    1.8     0.0     0.0   492.0     0.0     0.0     0.0     0.0     1.0    29.8
 9  7 80 191623  800 3.00    2.6     0.0     0.0   185.9     0.0     0.0     0.0     0.0     0.0     0.0
 9  7 80 191624  800 3.00    2.0     0.0     0.0    98.5     0.0     0.0     0.0     0.0     0.0     0.0
 9  7 80 191625  800 3.00    2.5     0.0     0.0     3.3     0.0     0.0     0.0     0.0     0.0     0.0
 9  7 80 191626  800 3.00    2.2     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 9  7 80 191628  800 3.00    2.3     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 9  7 80 191629  800 3.00    2.5     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 9  7 80 191630  800 3.00    2.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 9  7 80 191631  800 3.00    2.9     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 9  7 80 191632  800 3.00    2.8     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 9  7 80 191633  800 3.00    2.6     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 9  7 80 191634  800 3.00    3.4     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 9  7 80 191635  800 3.00    2.3     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 9  7 80 191636  800 3.00    2.1     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 9  7 80 191637  800 3.00    2.6     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
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DD MM YY  RECEP  HR  SHRS      OBS      PUFF2     PLUME    MSPUFF      RTM2      RADM      ****     ARRPA    PUFF1       A
 34
 9  7 80 191600 1100 3.00      2.7        0.0       0.0       0.0       0.0       0.0       0.0       0.0      0.0       0.0
 9  7 80 191601 1100 3.00      2.0        0.0       0.0       0.0       0.0       0.0       0.0       0.0      0.0       0.0
 9  7 80 191602 1100 3.00      3.5        0.0       0.0       0.0       0.0       0.0       0.0       0.0      0.0       0.0
 9  7 80 191603 1100 3.00      2.3        0.0       0.0       0.0       0.0       0.0       0.0       0.0      0.0       0.0
 9  7 80 191604 1100 3.00      2.6        0.0       0.0       0.0       0.0       0.0       0.0       0.0      0.0       0.0
 9  7 80 191606 1100 3.00     10.5        0.0       0.0       0.0       0.0       0.0       0.0       0.0      0.0       0.0
 9  7 80 191607 1100 3.00      2.8        0.0       0.0       0.0       0.0       0.0       0.0       0.0      0.0       0.0
 9  7 80 191609 1100 3.00     63.0        0.0       0.0       0.0       0.0       0.0       0.0       0.0      0.0       0.0
 9  7 80 191610 1100 3.00    820.0        0.0       0.0       0.0       0.0       0.0       0.0       0.0      0.0       0.0
 9  7 80 191611 1100 3.00    530.0        0.0       0.0       0.0       0.0       0.0       0.0       0.0      0.0       0.0
 9  7 80 191612 1100 3.00    186.0        0.0       0.0       0.0       0.0       0.0       0.0       0.0      0.0       0.0
 9  7 80 191613 1100 3.00    500.0        0.0       0.0       0.0       0.0       0.0       0.0       0.0      0.0       0.0
 9  7 80 191615 1100 3.00      2.6        0.0      30.7       0.0       0.0       0.0       0.0      25.0     12.6      23.4
 9  7 80 191616 1100 3.00      2.5        0.0      33.0       0.0       0.0       0.0       0.0      57.5     19.9      25.7
 9  7 80 191617 1100 3.00      2.4        0.0     103.8       0.0       0.0       0.0       0.0     903.5     72.0      81.0
 9  7 80 191618 1100 3.00      2.3        0.0     389.3       0.0       0.0       0.0       0.0    2449.2    270.7     300.0
 9  7 80 191619 1100 3.00      2.6        0.0     442.0       1.7       0.0       0.0       0.0     444.7    289.2     344.2
 9  7 80 191620 1100 3.00      1.7        0.0     658.5      53.8       0.0       0.0       0.0       0.2    485.6     511.4
 9  7 80 191623 1100 3.00      2.5        0.0     109.6     590.6       0.0       0.0       0.0       0.0     48.5      83.2
 9  7 80 191624 1100 3.00      2.0        0.0      11.6     813.2       0.0       0.0       0.0       0.0      6.0       8.9
 9  7 80 191625 1100 3.00      2.7        0.0       0.0     577.3       0.0       0.0       0.0       0.0      0.3       0.0
 9  7 80 191626 1100 3.00      2.2        0.0       0.0     278.1       0.0       0.0       0.0       0.0      0.0       0.0
 9  7 80 191627 1100 3.00      2.6        0.0       0.0     221.2       0.0       0.0       0.0       0.0      0.0       0.0
 9  7 80 191628 1100 3.00      2.7        0.0       0.0       4.7       0.0       0.0       0.0       0.0      0.0       0.0
 9  7 80 191629 1100 3.00      2.5        0.0       0.0       0.7       0.0       0.0       0.0       0.0      0.0       0.0
 9  7 80 191630 1100 3.00      2.4        0.0       0.0       0.0       0.0       0.0       0.0       0.0      0.0       0.0
 9  7 80 191631 1100 3.00      3.3        0.0       0.0       0.0       0.0       0.0       0.0       0.0      0.0       0.0
 9  7 80 191632 1100 3.00      2.8        0.0       0.0       0.0       0.0       0.0       0.0       0.0      0.0       0.0
 9  7 80 191633 1100 3.00      2.6        0.0       0.0       0.0       0.0       0.0       0.0       0.0      0.0       0.0
 9  7 80 191634 1100 3.00      2.9        0.0       0.0       0.0       0.0       0.0       0.0       0.0      0.0       0.0
 9  7 80 191635 1100 3.00      2.4        0.0       0.0       0.0       0.0       0.0       0.0       0.0      0.0       0.0
 9  7 80 191636 1100 3.00      2.0        0.0       0.0       0.0       0.0       0.0       0.0       0.0      0.0       0.0
 9  7 80 191637 1100 3.00      2.3        0.0       0.0       0.0       0.0       0.0       0.0       0.0      0.0       0.0
 9  7 80 191638 1100 3.00      2.1        0.0       0.0       0.0       0.0       0.0       0.0       0.0      0.0       0.0
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DD MM YY  RECEP  HR  SHRS      OBS    PUFF2    PLUME   MSPUFF     RTM2     RADM     ****    ARRPA    PUFF1     ARM3
 32
 9  7 80 191600 1400 3.00      2.7      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 9  7 80 191601 1400 3.00      1.7      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 9  7 80 191602 1400 3.00      3.1      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 9  7 80 191603 1400 3.00      2.3      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 9  7 80 191604 1400 3.00      2.7      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 9  7 80 191606 1400 3.00      2.6      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 9  7 80 191609 1400 3.00      3.9      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 9  7 80 191610 1400 3.00     26.0      0.4      0.0      0.0      0.0      0.0      0.0      0.0      0.0      1.0
 9  7 80 191611 1400 3.00    164.0      4.1      0.0      0.0      0.0      0.0      0.0      0.0      0.0      9.2
 9  7 80 191612 1400 3.00     99.0     13.4      0.0      0.0      0.1      0.0      0.0      0.0      0.0     29.4
 9  7 80 191613 1400 3.00    350.0     10.9      0.0      0.0      0.0      0.0      0.0      0.0      0.0     24.8
 9  7 80 191615 1400 3.00      4.5    113.4      0.0      0.0      1.3      0.0      0.0      0.0      0.0    253.7
 9  7 80 191616 1400 3.00      4.3    103.9      4.2      0.0      1.8      0.0      0.0      0.1      3.1    231.0
 9  7 80 191617 1400 3.00      2.9    139.2     53.4      0.0      1.1      0.0      0.0    308.1     51.5    315.7
 9  7 80 191618 1400 3.00      2.5    158.9    185.4      0.0      2.3      0.0      0.0    888.7    203.6    353.2
 9  7 80 191619 1400 3.00      2.5     69.1    423.8      0.6      1.0      0.0      0.0    574.7    482.6    152.5
 9  7 80 191620 1400 3.00      2.4     27.1    509.2     17.9      2.1      0.0      0.0      0.5    745.8     62.3
 9  7 80 191623 1400 3.00      2.4      0.0    206.1    196.9      0.1      0.0      0.0      0.0    245.5      0.0
 9  7 80 191624 1400 3.00      2.0      0.0    168.6    271.1      0.0      0.0      0.0      0.0    145.7      0.0
 9  7 80 191625 1400 3.00      2.6      0.0      4.7    192.4      0.0      0.0      0.0      0.0     28.9      0.0
 9  7 80 191626 1400 3.00      2.2      0.0      0.0     94.5      0.0      0.0      0.0      0.0      0.0      0.0
 9  7 80 191627 1400 3.00      2.6      0.0      0.0     75.4      0.0      0.0      0.0      0.0      0.0      0.0
 9  7 80 191628 1400 3.00      2.0      0.0      0.0      2.6      0.0      0.0      0.0      0.0      0.0      0.0
 9  7 80 191629 1400 3.00      2.4      0.0      0.0      0.5      0.0      0.0      0.0      0.0      0.0      0.0
 9  7 80 191631 1400 3.00      2.8      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 9  7 80 191632 1400 3.00      2.7      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 9  7 80 191633 1400 3.00      2.6      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 9  7 80 191634 1400 3.00      2.6      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 9  7 80 191635 1400 3.00      2.5      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 9  7 80 191636 1400 3.00      2.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 9  7 80 191637 1400 3.00      2.3      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 9  7 80 191638 1400 3.00      2.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
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DD MM YY  RECEP  HR   SHRS     OBS      PUFF2     PLUME    MSPUFF      RTM2      RADM      ****     ARRPA   PUFF1     ARM3
 32
 9  7 80 191600 1700 3.00      2.4       0.0       0.0       0.0       0.0       0.0       0.0       0.0     0.0       0.0
 9  7 80 191601 1700 3.00      1.7       0.0       0.0       0.0       0.0       0.0       0.0       0.0     0.0       0.0
 9  7 80 191602 1700 3.00      2.8       0.0       0.0       0.0       0.0       0.0       0.0       0.0     0.0       0.0
 9  7 80 191603 1700 3.00      2.2       0.0       0.0       0.0       0.0       0.0       0.0       0.0     0.0       0.0
 9  7 80 191604 1700 3.00      2.6       0.0       0.0       0.0       0.0       0.0       0.0       0.0     0.0       0.0
 9  7 80 191605 1700 3.00      2.3       0.0       0.0       0.0       0.0       0.0       0.0       0.0     0.0       0.0
 9  7 80 191606 1700 3.00      2.6       0.0       0.0       0.0       0.0       0.0       0.0       0.0     0.0       0.0
 9  7 80 191607 1700 3.00      2.8       0.0       0.0       0.0       0.0       0.0       0.0       0.0     0.0       0.0
 9  7 80 191609 1700 3.00      3.2       0.0       0.0       0.0       0.0       0.0       0.0       0.0     0.0       0.0
 9  7 80 191610 1700 3.00      2.7       0.0       0.0       0.0       0.0       0.0       0.0       0.0     0.0       0.0
 9  7 80 191611 1700 3.00     28.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0     0.0       0.0
 9  7 80 191612 1700 3.00     32.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0     0.0       0.0
 9  7 80 191613 1700 3.00     66.0       0.3       0.0       0.0       0.0       0.0       0.0       0.0     0.0       0.6
 9  7 80 191615 1700 3.00     11.0      18.3       0.0       0.0       0.9       0.0       0.0       0.0     0.0      33.7
 9  7 80 191616 1700 3.00      6.4      42.0       0.0       0.0       1.4       8.7       0.0       0.0     0.0      76.6
 9  7 80 191617 1700 3.00      3.0     110.5      17.8       0.0       2.5     285.7       0.0     102.7    17.2     199.2
 9  7 80 191619 1700 3.00      2.5     118.0     141.3       0.2       2.7       0.0       0.0     191.6   178.9     214.1
 9  7 80 191620 1700 3.00      2.9      32.1     169.7       6.0       1.3       0.0       0.0       0.2   269.1      58.7
 9  7 80 191623 1700 3.00      2.5       0.0      68.7      65.6       0.3       0.0       0.0       0.0   110.4       0.0
 9  7 80 191624 1700 3.00      2.0       0.0      56.2      90.4       0.2       0.0       0.0       0.0   116.8       0.0
 9  7 80 191625 1700 3.00      2.5       0.0       1.6      64.1       0.1       0.0       0.0       0.0    17.6       0.0
 9  7 80 191627 1700 3.00      2.4       0.0       0.0      25.1       0.0       0.0       0.0       0.0     0.0       0.0
 9  7 80 191628 1700 3.00      2.2       0.0       0.0       0.9       0.0       0.0       0.0       0.0     0.0       0.0
 9  7 80 191629 1700 3.00      2.3       0.0       0.0       0.2       0.0       0.0       0.0       0.0     0.0       0.0
 9  7 80 191630 1700 3.00      1.9       0.0       0.0       0.0       0.0       0.0       0.0       0.0     0.0       0.0
 9  7 80 191631 1700 3.00      2.9       0.0       0.0       0.0       0.0       0.0       0.0       0.0     0.0       0.0
 9  7 80 191632 1700 3.00      2.3       0.0       0.0       0.0       0.0       0.0       0.0       0.0     0.0       0.0
 9  7 80 191633 1700 3.00      2.4       0.0       0.0       0.0       0.0       0.0       0.0       0.0     0.0       0.0
 9  7 80 191634 1700 3.00      2.6       0.0       0.0       0.0       0.0       0.0       0.0       0.0     0.0       0.0
 9  7 80 191636 1700 3.00      2.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0     0.0       0.0
 9  7 80 191637 1700 3.00      2.5       0.0       0.0       0.0       0.0       0.0       0.0       0.0     0.0       0.0
 9  7 80 191638 1700 3.00      1.8       0.0       0.0       0.0       0.0       0.0       0.0       0.0     0.0       0.0
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DD MM YY  RECEP   HR  SHRS     OBS  PUFF2  PLUME MSPUFF   RTM2   RADM   ****  ARRPA  PUFF1   ARM3
33
 9  7 80 191600 2000 3.00      2.5    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
 9  7 80 191601 2000 3.00      1.7    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
 9  7 80 191602 2000 3.00      2.4    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
 9  7 80 191603 2000 3.00      3.1    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
 9  7 80 191604 2000 3.00      2.5    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
 9  7 80 191605 2000 3.00      2.9    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
 9  7 80 191606 2000 3.00      2.9    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
 9  7 80 191607 2000 3.00      2.4    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
 9  7 80 191609 2000 3.00      2.6    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
 9  7 80 191610 2000 3.00      3.6    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
 9  7 80 191611 2000 3.00      5.3    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
 9  7 80 191612 2000 3.00      4.1    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
 9  7 80 191615 2000 3.00      6.4    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
 9  7 80 191616 2000 3.00      5.7    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
 9  7 80 191617 2000 3.00      3.2   36.8    5.9    0.0    0.8   95.2    0.0   34.2    5.7    3.2
 9  7 80 191619 2000 3.00      2.4   39.3   47.1    0.1    0.9    0.0    0.0   63.9   59.6   34.4
 9  7 80 191620 2000 3.00      2.4   10.7   56.6    2.0    0.4    0.0    0.0    0.1   89.7   51.8
 9  7 80 191623 2000 3.00      2.3    0.0   22.9   21.9    0.1    0.0    0.0    0.0   36.8   20.6
 9  7 80 191624 2000 3.00      2.1    0.0   18.7   30.1    0.1    0.0    0.0    0.0   40.5   23.4
 9  7 80 191625 2000 3.00      2.4    0.0    0.5   21.4    0.0    0.0    0.0    0.0    5.9    3.4
 9  7 80 191626 2000 3.00      2.1    0.0    0.0   10.5    0.0    0.0    0.0    0.0    0.1    0.0
 9  7 80 191627 2000 3.00      2.4    0.0    0.0    8.4    0.0    0.0    0.0    0.0    0.0    0.0
 9  7 80 191628 2000 3.00      2.1    0.0    0.0    0.3    0.0    0.0    0.0    0.0    0.0    0.0
 9  7 80 191629 2000 3.00      2.5    0.0    0.0    0.1    0.0    0.0    0.0    0.0    0.0    0.0
 9  7 80 191630 2000 3.00      1.9    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
 9  7 80 191631 2000 3.00      3.1    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
 9  7 80 191632 2000 3.00      2.6    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
 9  7 80 191633 2000 3.00      2.5    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
 9  7 80 191634 2000 3.00      2.5    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
 9  7 80 191635 2000 3.00      2.3    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
 9  7 80 191636 2000 3.00      2.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
 9  7 80 191637 2000 3.00      2.1    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
 9  7 80 191638 2000 3.00      1.7    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
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DD MM YY  RECEP   HR  SHRS      OBS     PUFF2     PLUME    MSPUFF      RTM2      RADM      ****     ARRPA     PUFF1      ARM3
 30
 9  7 80 191601 2300 3.00       1.5       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 9  7 80 191602 2300 3.00       2.4       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 9  7 80 191604 2300 3.00       2.3       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 9  7 80 191605 2300 3.00       2.9       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 9  7 80 191606 2300 3.00       3.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 9  7 80 191607 2300 3.00       3.2       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 9  7 80 191609 2300 3.00       2.7       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 9  7 80 191610 2300 3.00       2.8       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 9  7 80 191611 2300 3.00       2.4       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 9  7 80 191612 2300 3.00       2.6       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 9  7 80 191615 2300 3.00       2.5       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 9  7 80 191616 2300 3.00       2.7       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 9  7 80 191617 2300 3.00       2.5      12.3       2.0       0.0       0.3      31.7       0.0      11.4       1.9       2.2
 9  7 80 191619 2300 3.00       2.4      13.1      15.7       0.0       0.3       0.0       0.0      21.3      19.9      17.0
 9  7 80 191620 2300 3.00       2.3       3.6      18.9       0.7       0.1       0.0       0.0       0.0      29.9      20.6
 9  7 80 191623 2300 3.00       2.3       0.0       7.6       7.3       0.0       0.0       0.0       0.0      12.3       8.3
 9  7 80 191624 2300 3.00       2.1       0.0       6.2      10.0       0.0       0.0       0.0       0.0      13.5       6.6
 9  7 80 191625 2300 3.00       2.4       0.0       0.2       7.1       0.0       0.0       0.0       0.0       2.0       0.2
 9  7 80 191627 2300 3.00       2.4       0.0       0.0       2.8       0.0       0.0       0.0       0.0       0.0       0.0
 9  7 80 191628 2300 3.00       2.1       0.0       0.0       0.1       0.0       0.0       0.0       0.0       0.0       0.0
 9  7 80 191629 2300 3.00       2.5       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 9  7 80 191630 2300 3.00       1.9       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 9  7 80 191631 2300 3.00       2.8       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 9  7 80 191632 2300 3.00       2.6       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 9  7 80 191633 2300 3.00       2.5       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 9  7 80 191634 2300 3.00       2.6       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 9  7 80 191635 2300 3.00       2.3       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 9  7 80 191636 2300 3.00       2.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 9  7 80 191637 2300 3.00       2.6       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 9  7 80 191638 2300 3.00       1.8       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 16
11  7 80 193114 2200 0.75       3.6       0.0      34.1       0.0       0.0       0.0       0.0       0.0      26.8       0.0
11  7 80 193115 2200 0.75       3.0       0.0     139.9       0.0       0.0       0.0       0.0       0.0     105.0       0.0
11  7 80 193116 2200 0.75       3.8       0.0     273.4       3.1       0.0       0.0       0.0       0.0     181.6       0.0
11  7 80 193117 2200 0.75       2.0       0.4     470.4      40.3       0.0       0.0       0.0       0.0     280.0     103.1
11  7 80 193118 2200 0.75       4.5       0.9     584.8     179.5       0.0       0.0       0.0       0.0     304.1     232.9
11  7 80 193119 2200 0.75       2.0       0.0     502.0     157.4       0.0       0.0       0.0       0.0     158.9       0.0
11  7 80 193120 2200 0.75       4.2       0.0     272.6      73.4       0.0       0.0       0.0       0.0      53.3       0.0
11  7 80 193121 2200 0.75       3.5       0.0     138.4      23.2       0.0       0.0       0.0       0.0      18.7       0.0
11  7 80 193122 2200 0.75      10.0       0.0      58.9     117.8       0.0       0.0       0.0       0.0      12.9       0.0
11  7 80 193123 2200 0.75       4.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
11  7 80 193124 2200 0.75       8.2       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
11  7 80 193126 2200 0.75       3.5       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
11  7 80 193127 2200 0.75       2.4       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
11  7 80 193128 2200 0.75       2.4       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
11  7 80 193129 2200 0.75       2.4       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
11  7 80 193130 2200 0.75       2.4       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
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DD MM YY  RECEP   HR  SHRS     OBS    PUFF2    PLUME   MSPUFF    RTM2    RADM   ****   ARRPA   PUFF1   ARM3
 16
11  7 80 193114 2245 0.75     38.0      0.4    106.0      0.0   118.9      2.0    0.0     0.1   114.5   196.2
11  7 80 193115 2245 0.75     50.0     20.0    299.0     13.9    91.5     92.9    0.0     0.6   275.5   477.1
11  7 80 193116 2245 0.75    110.0     62.8    447.7    117.3    69.5    255.6    0.0     3.6   364.1   619.3
11  7 80 193117 2245 0.75     12.0    176.0    554.5    502.9    61.0    356.9    0.0    17.0   396.7   662.5
11  7 80 193118 2245 0.75     75.0    298.5    508.5   1230.2    75.5    407.8    0.0    45.0   320.1   541.8
11  7 80 193119 2245 0.75     40.0    174.3    321.5   1366.7   114.0    210.7    0.0    93.5   161.2   278.0
11  7 80 193120 2245 0.75     38.0     55.3    220.9    748.9   128.2     37.0    0.0     0.0    51.2    85.7
11  7 80 193121 2245 0.75    127.0     16.7     88.7    323.3     1.7      5.6    0.0     0.0    18.6    31.6
11  7 80 193122 2245 0.75    300.0     14.8     19.6    126.0     1.0      3.0    0.0   395.5     4.3     7.2
11  7 80 193123 2245 0.75    219.0      0.0      0.0      0.0     1.5      0.0    0.0   336.9     0.0     0.0
11  7 80 193124 2245 0.75     56.0      0.0      0.0      0.0     2.5      0.0    0.0   256.4     0.0     0.0
11  7 80 193126 2245 0.75      3.9      0.0      0.0      0.0     2.6      0.0    0.0     0.0     0.0     0.0
11  7 80 193127 2245 0.75      2.4      0.0      0.0      0.0     0.0      0.0    0.0     0.0     0.0     0.0
11  7 80 193128 2245 0.75      2.4      0.0      0.0      0.0     0.0      0.0    0.0     0.0     0.0     0.0
11  7 80 193129 2245 0.75      2.4      0.0      0.0      0.0     0.0      0.0    0.0     0.0     0.0     0.0
11  7 80 193130 2245 0.75      2.4      0.0      0.0      0.0     0.0      0.0    0.0     0.0     0.0     0.0
 16
11  7 80 193114 2330 0.75    270.0      1.0    126.2      0.0   225.9     16.0    0.0     3.5   227.1   337.2
11  7 80 193115 2330 0.75    280.0     56.1    704.0     62.4   183.0    264.8    0.0     5.5   406.2   613.6
11  7 80 193116 2330 0.75    241.0    171.5    640.1    306.5   148.4    772.2    0.0    23.4   453.3   679.4
11  7 80 193117 2330 0.75    180.0    419.9    414.4   1010.7   126.3   1080.4    0.0    80.1   403.6   606.7
11  7 80 193118 2330 0.75    259.0    618.7    313.6   1988.1   150.1   1157.3    0.0   162.9   266.8   395.2
11  7 80 193119 2330 0.75    330.0    393.2    154.2   1953.4   212.0    703.6    0.0   262.5   124.3   182.0
11  7 80 193120 2330 0.75    302.0    137.2    130.0    969.4   235.8    170.1    0.0   204.0    36.1    54.1
11  7 80 193121 2330 0.75    360.0     48.8     42.5    405.8    11.1     36.5    0.0   195.7    12.6    19.1
11  7 80 193122 2330 0.75    200.0     16.9      0.0     90.7    10.6      4.6    0.0   493.3     0.0     0.0
11  7 80 193123 2330 0.75    145.0      0.0      0.0      0.0    14.3      0.0    0.0   375.3     0.0     0.0
11  7 80 193124 2330 0.75     76.0      0.0      0.0      0.0    20.6      0.0    0.0   273.7     0.0     0.0
11  7 80 193126 2330 0.75     14.0      0.0      0.0      0.0    17.8      0.0    0.0     1.4     0.0     0.0
11  7 80 193127 2330 0.75      2.4      0.0      0.0      0.0     0.4      0.0    0.0     0.1     0.0     0.0
11  7 80 193128 2330 0.75      2.4      0.0      0.0      0.0     0.6      0.0    0.0     0.0     0.0     0.0
11  7 80 193129 2330 0.75      2.4      0.0      0.0      0.0     0.9      0.0    0.0     0.0     0.0     0.0
11  7 80 193130 2330 0.75      2.4      0.0      0.0      0.0     0.0      0.0    0.0     0.0     0.0     0.0
 15
12  7 80 194114   15 0.75    178.0      1.8     94.9      0.0   321.1     42.2    0.0    10.2   364.6     1.3
12  7 80 194115   15 0.75    190.0    108.3   1355.0    145.4   274.6    515.6    0.0    14.6   497.1    83.0
12  7 80 194116   15 0.75    142.0    326.2    850.6    570.6   236.5   1549.8    0.0    59.6   449.1   242.0
12  7 80 194117   15 0.75     90.0    732.3     50.3   1563.7   196.1   2170.4    0.0   189.3   300.9   551.4
12  7 80 194118   15 0.75    216.0    961.2      0.0   2453.3   223.8   2248.5    0.0   353.8   144.1   721.6
12  7 80 194120   15 0.75    236.0    245.9      0.0    734.6   322.9    399.1    0.0   612.1     7.8   189.2
12  7 80 194121   15 0.75    126.0     96.2      0.0    270.6    28.0     92.7    0.0   587.0     0.7    74.2
12  7 80 194122   15 0.75    100.0      6.2      0.0     11.9    28.8      4.8    0.0   293.4     0.0     4.6
12  7 80 194123   15 0.75     46.0      0.0      0.0      0.0    38.4      0.0    0.0   115.2     0.0     0.0
12  7 80 194124   15 0.75     33.0      0.0      0.0      0.0    54.2      0.0    0.0    52.0     0.0     0.0
12  7 80 194126   15 0.75      7.9      0.0      0.0      0.0    45.8      0.0    0.0     4.2     0.0     0.0
12  7 80 194127   15 0.75      2.4      0.0      0.0      0.0     1.3      0.0    0.0     0.3     0.0     0.0
12  7 80 194128   15 0.75      2.4      0.0      0.0      0.0     1.9      0.0    0.0     0.1     0.0     0.0
12  7 80 194129   15 0.75      2.4      0.0      0.0      0.0     2.6      0.0    0.0     0.0     0.0     0.0
12  7 80 194130   15 0.75      2.4      0.0      0.0      0.0     0.0      0.0    0.0     0.0     0.0     0.0
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DD MM YY  RECEP  HR  SHRS     OBS    PUFF2   PLUME  MSPUFF   RTM2    RADM    ****   ARRPA  PUFF1    ARM3
 14
12  7 80 194114  100 0.75    65.0     59.3     0.0     0.0  210.8   167.6     0.0    26.1  354.7    95.5
12  7 80 194116  100 0.75    68.0    726.3    33.4   855.2  217.2  1672.0     0.0   455.7  324.9  1216.8
12  7 80 194117  100 0.75    50.0    935.5     0.0  1857.9  140.9  2009.1     0.0   998.5  164.3  1550.0
12  7 80 194118  100 0.75    99.0    680.8     0.0  2315.2  149.4  1646.9     0.0  1306.1   57.8  1089.0
12  7 80 194120  100 0.75    66.0     96.8     0.0   436.8  177.2   148.2     0.0   725.0    0.0   160.2
12  7 80 194121  100 0.75    42.0     38.8     0.0   129.2   47.9    26.1     0.0   461.7    0.0    64.2
12  7 80 194122  100 0.75    40.0      0.0     0.0     0.0   56.5     0.0     0.0    63.5    0.0     0.0
12  7 80 194123  100 0.75    20.0      0.0     0.0     0.0   67.9     0.0     0.0    13.7    0.0     0.0
12  7 80 194124  100 0.75    25.0      0.0     0.0     0.0   84.8     0.0     0.0     4.7    0.0     0.0
12  7 80 194126  100 0.75     3.5      0.0     0.0     0.0   48.2     0.0     0.0     0.2    0.0     0.0
12  7 80 194127  100 0.75     2.4      0.0     0.0     0.0    2.5     0.0     0.0     0.0    0.0     0.0
12  7 80 194128  100 0.75     2.4      0.0     0.0     0.0    4.5     0.0     0.0     0.0    0.0     0.0
12  7 80 194129  100 0.75     2.4      0.0     0.0     0.0    7.3     0.0     0.0     0.0    0.0     0.0
12  7 80 194130  100 0.75     2.4      0.0     0.0     0.0    0.0     0.0     0.0     0.0    0.0     0.0
 14
12  7 80 194114  145 0.75    37.0    395.1     0.0     0.0  157.2   936.7     0.0     8.7  126.9     0.0
12  7 80 194115  145 0.75     1.0    734.0     8.3   114.9  158.7  1450.4     0.0    49.3  152.5    42.4
12  7 80 194116  145 0.75    25.0    734.4    11.1   376.0  159.5  1746.9     0.0   151.9  122.4   135.4
12  7 80 194117  145 0.75    28.0    559.7     0.0   772.4  120.6  1468.1     0.0   332.8   61.2   283.6
12  7 80 194118  145 0.75    49.0    304.4     0.0   929.1  125.5   763.9     0.0   435.4   20.8   347.9
12  7 80 194120  145 0.75    30.0     38.6     0.0   226.0  141.2    51.6     0.0   310.6    0.0    82.4
12  7 80 194121  145 0.75    21.0     14.6     0.0    71.8   46.7     8.7     0.0   183.2    0.0    25.9
12  7 80 194122  145 0.75    20.0      0.0     0.0     0.0   56.5     0.0     0.0    21.2    0.0     0.0
12  7 80 194124  145 0.75     9.3      0.0     0.0     0.0   80.7     0.0     0.0     1.6    0.0     0.0
12  7 80 194126  145 0.75     3.1      0.0     0.0     0.0   40.3     0.0     0.0     0.1    0.0     0.0
12  7 80 194127  145 0.75     2.4      0.0     0.0     0.0    1.5     0.0     0.0     0.0    0.0     0.0
12  7 80 194128  145 0.75     2.4      0.0     0.0     0.0    3.1     0.0     0.0     0.0    0.0     0.0
12  7 80 194129  145 0.75     2.4      0.0     0.0     0.0    5.7     0.0     0.0     0.0    0.0     0.0
12  7 80 194130  145 0.75     2.4      0.0     0.0     0.0    0.0     0.0     0.0     0.0    0.0     0.0
 14
12  7 80 194114  230 0.75    13.0    555.9     0.0     0.0  119.7  1140.8     0.0     0.0    8.7     0.0
12  7 80 194115  230 0.75     2.0    714.6     0.0    26.7  120.0  1393.0     0.0     0.0   14.0    79.4
12  7 80 194116  230 0.75     9.5    544.4     0.0    91.0  120.4  1320.5     0.0     0.0   14.1   279.7
12  7 80 194117  230 0.75    12.0    261.0     0.0   153.1   99.0   808.1     0.0     0.0    6.4   464.2
12  7 80 194118  230 0.75    24.0     79.6     0.0   157.4  102.2   214.9     0.0     0.0    1.5   484.4
12  7 80 194120  230 0.75    23.0      6.3     0.0    80.4  112.2     2.2     0.0    68.9    0.0   244.0
12  7 80 194121  230 0.75    11.0      1.7     0.0    28.8   41.5     0.0     0.0    29.3    0.0    86.5
12  7 80 194123  230 0.75     6.0      0.0     0.0     0.0   61.9     0.0     0.0     0.0    0.0     0.0
12  7 80 194124  230 0.75     5.5      0.0     0.0     0.0   73.4     0.0     0.0     0.0    0.0     0.0
12  7 80 194126  230 0.75     3.1      0.0     0.0     0.0   31.0     0.0     0.0     0.0    0.0     0.0
12  7 80 194127  230 0.75     2.4      0.0     0.0     0.0    0.9     0.0     0.0     0.0    0.0     0.0
12  7 80 194128  230 0.75     2.4      0.0     0.0     0.0    2.2     0.0     0.0     0.0    0.0     0.0
12  7 80 194129  230 0.75     2.4      0.0     0.0     0.0    4.3     0.0     0.0     0.0    0.0     0.0
12  7 80 194130  230 0.75     2.4      0.0     0.0     0.0    0.0     0.0     0.0     0.0    0.0     0.0
```

```
DD MM YY  RECEP   HR  SHRS     OBS     PUFF2   PLUME  MSPUFF    RTM2    RADM    ****   ARRPA  PUFF1   ARM3
 14
12  7 80 194114  315 0.75      5.4    541.9     0.0     0.0    98.3   780.0     0.0     0.0    0.0    0.0
12  7 80 194115  315 0.75      2.0    329.3     0.0     0.0    99.0   731.0     0.0     0.0    0.0    0.0
12  7 80 194116  315 0.75      5.3    156.3     0.0     0.0   100.0   392.9     0.0     0.0    0.0    0.0
12  7 80 194118  315 0.75     10.0      6.5     0.0     0.0    79.7     0.0     0.0     0.0    0.0    0.0
12  7 80 194120  315 0.75      7.7      0.0     0.0     0.0    90.0     0.0     0.0     0.0    0.0    0.0
12  7 80 194121  315 0.75      1.0      0.0     0.0     0.0    32.1     0.0     0.0     0.0    0.0    0.0
12  7 80 194122  315 0.75      5.0      0.0     0.0     0.0    46.9     0.0     0.0     0.0    0.0    0.0
12  7 80 194123  315 0.75      3.0      0.0     0.0     0.0    54.2     0.0     0.0     0.0    0.0    0.0
12  7 80 194124  315 0.75      5.4      0.0     0.0     0.0    62.8     0.0     0.0     0.0    0.0    0.0
12  7 80 194126  315 0.75      3.3      0.0     0.0     0.0    20.3     0.0     0.0     0.0    0.0    0.0
12  7 80 194127  315 0.75      2.4      0.0     0.0     0.0     0.7     0.0     0.0     0.0    0.0    0.0
12  7 80 194128  315 0.75      2.4      0.0     0.0     0.0     1.7     0.0     0.0     0.0    0.0    0.0
12  7 80 194129  315 0.75      2.4      0.0     0.0     0.0     3.3     0.0     0.0     0.0    0.0    0.0
12  7 80 194130  315 0.75      2.4      0.0     0.0     0.0     0.0     0.0     0.0     0.0    0.0    0.0
```

Appendix G

Tables of predicted and observed tracer concentrations (pCi/m^3) for the Savannah River Plant data set. (Note: Observations include 16 pCi/m^3 background.)

Legend

MM = Month
DD = Day of month
YY = Year
RECEP = Receptor identifier
JDY = Julian day
REC = Receptor identifier
HR = Sampling starting time
SHRS = Sampling interval (hours)
OBS = Observation (with 16 pCi/m^3 background)
PUFF2 = MESOPUFF-II
PLUME = MESOPLUME
PUFF1 = MESOPUFF-I

```
MM DD YY JDY REC HR   SHRS    OBS    PUFF2   PLUME  MSPUFF    RTM2    RADM  ****  ****   PUFF1    ARM3
 7
 5 10 76 279  2 2200  14.0  188.8   237.3   159.5     0.0   294.9     7.7   0.0   0.0   190.2   332.9
 5 10 76 279  5 2200  14.0   17.0     0.0     0.0     0.0     0.0     0.0   0.0   0.0     0.0     0.0
 5 10 76 279  6 2200  14.0   17.4     0.0     0.0     0.0     0.0     0.0   0.0   0.0     0.0     0.0
 5 10 76 279 10 2200  14.0   15.5    19.7     0.0   156.7     0.0     0.0   0.0   0.0     0.0     0.0
 5 10 76 279 11 2200  14.0   15.1    16.8     0.0   504.9     0.0     0.0   0.0   0.0     0.0     0.0
 5 10 76 279 12 2200  14.0  376.0    85.9   156.0   129.3   280.1     0.0   0.0   0.0    97.7   174.6
 5 10 76 279 14 2200  14.0  675.9    24.7   389.2     0.0  1756.4  4530.5   0.0   0.0   509.9   880.9
12
14 10 76 288  2 2200  15.0   16.7     0.0     0.0     0.0     0.0     0.0   0.0   0.0     0.0     0.0
14 10 76 288  3 2300  13.0   18.0     0.0     0.0     0.0     0.0     0.0   0.0   0.0     0.0     0.0
14 10 76 288  4 2200  14.0   14.9     0.0     0.0     0.0     0.0     0.0   0.0   0.0     0.0     0.0
14 10 76 288  5 2200  14.0   15.3     0.0     0.0     0.0     0.0     0.0   0.0   0.0     0.0     0.0
14 10 76 288  6 2200  14.0   16.9    21.4     0.0     0.0    76.4     0.0   0.0   0.0     4.0     0.0
14 10 76 288  7 2200  15.0   15.6   614.5   388.3   262.5   312.1     0.0   0.0   0.0   277.8   111.8
14 10 76 288  9 2200  14.0   15.6     0.0   923.8     0.0   338.1     0.0   0.0   0.0  1321.7   272.5
14 10 76 288 10 2200  13.0   47.6     0.0     0.0     0.0    12.5     0.0   0.0   0.0     0.0     0.0
14 10 76 288 11 2155  14.0   15.2     0.0     0.0     0.0     0.1     0.0   0.0   0.0     0.0     0.0
14 10 76 288 12 2200  14.0   15.4     0.0     0.0     0.0     0.0     0.0   0.0   0.0     0.0     0.0
14 10 76 288 13 2100  15.0   15.3     0.0     0.0     0.0     0.2     0.0   0.0   0.0     0.3     0.0
14 10 76 288 14 2225  14.0   15.3     0.0     0.0     0.0     0.0     0.0   0.0   0.0     0.0     0.0
11
15 10 76 289  2 1300   8.0   15.3     0.0     0.0     0.0     0.0     0.0   0.0   0.0     0.0     0.0
15 10 76 289  3 1200   7.0   15.8     0.0     0.0     0.0     0.0     0.0   0.0   0.0     0.0     0.0
15 10 76 289  4 1300   8.0   17.1     0.0     0.0     0.0     0.0     0.0   0.0   0.0     0.0     0.0
15 10 76 289  5 1300   8.0   20.2     2.6     0.0     0.0     0.0     0.0   0.0   0.0     0.0     2.0
15 10 76 289  6 1300   8.0   15.5     3.2     0.0     0.0     0.0     0.0   0.0   0.0     0.0     2.5
15 10 76 289  7 1300   8.0   17.0     0.0     0.0     0.0     0.6     0.0   0.0   0.0     0.0     0.0
15 10 76 289  8 1345   7.3   49.0   456.5     0.0   176.3    62.5     0.0   0.0   0.0     0.0   350.4
15 10 76 289  9 1300   7.9   44.4     0.0   309.9     0.0   230.6     0.0   0.0   0.0  1128.4     0.0
15 10 76 289 10 1200   9.0   36.6     0.0     0.0     0.0    17.7     0.0   0.0   0.0     0.0     0.0
15 10 76 289 12 1300   8.0   15.9     0.0     0.0     0.0     0.0     0.0   0.0   0.0     0.0     0.0
15 10 76 289 13 1315   7.2   17.6     0.0    39.0     0.0    12.3     0.0   0.0   0.0     2.3     0.0
 1
15 10 76 289  9 2200  14.0  191.4   154.5     0.0     0.0   766.0     0.0   0.0   0.0     0.0     0.0
 9
29 10 76 303  2  900  10.0  194.7     0.0    22.1    17.1    29.6     0.0   0.0   0.0     4.4     6.8
29 10 76 303  3  900  10.0   16.0     0.0     0.0     0.0     0.0     0.0   0.0   0.0     0.0     0.0
29 10 76 303  4  900  10.0   16.2     0.0     0.0     0.0     0.0     0.0   0.0   0.0     0.0     0.0
29 10 76 303  5  900  10.0   15.9     0.0     0.0     0.0     0.0     0.0   0.0   0.0     0.0     0.0
29 10 76 303  6  900  10.0   15.6     0.0     0.0     0.0     0.0     0.0   0.0   0.0     0.0     0.0
20 10 76 303  7  900  10.0   15.6     0.0     0.0     0.0     0.0     0.0   0.0   0.0     0.0     0.0
29 10 76 303  9  900  10.0   15.8     0.0     0.0     0.0     0.0     0.0   0.0   0.0     0.0     0.0
29 10 76 303 10  900  10.0   15.7     0.0     0.0     0.0     0.0     0.0   0.0   0.0     0.0     0.0
29 10 76 303 14  900  10.0  347.0     0.0   245.7   212.6    54.2     0.0   0.0   0.0   146.9    76.3
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MM DD YY JDY REC HR   SHRS    OBS   PUFF2  PLUME  MSPUFF   RTM2   RADM   ****   ****  PUFF1   ARM3
 8
29 10 76 303   2 2100 10.0  157.6    0.1    3.7    0.0   30.6    0.0    0.0    0.0    2.0    0.7
29 10 76 303   3 2100 10.0   18.4    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
29 10 76 303   4 2100 10.0   15.7    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
29 10 76 303   5 2100 10.0   35.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
29 10 76 303   6 2100 10.0   15.8    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
29 10 76 303  10 2100 10.0   15.8    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
29 10 76 303  12 2100 10.0   15.6   15.3   70.5   87.9   41.5    0.0    0.0    0.0   64.2   25.8
29 10 76 303  14 2100 10.0  242.5   24.5    0.0    0.0   57.1    0.0    0.0    0.0    0.0    0.0
11
18 11 76 323   2 1000 10.0   17.1    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
18 11 76 323   3 1000 10.0   23.9    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
18 11 76 323   4 1000 10.0   17.9    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
18 11 76 323   6 1000 10.0   26.2    0.0    0.0    0.0    1.2    0.0    0.0    0.0    0.0    0.0
18 11 76 323   7 1000 10.0   20.3    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
18 11 76 323   8 1000 10.0   19.6    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
18 11 76 323  10 1000 10.0   17.2    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
18 11 76 323  11 1430  5.5   15.9    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
18 11 76 323  12 1000 10.0   16.1    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
18 11 76 323  13 1000 10.0   16.1    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
18 11 76 323  14 1000 10.0   17.3    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
12
18 11 76 323   2 2200 10.0   15.7    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
18 11 76 323   3 2200 10.0   15.8    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
18 11 76 323   4 2200 10.0   15.8    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
18 11 76 323   5 2200 10.0   16.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
18 11 76 323   6 2200 10.0   16.6    0.0    1.1  140.4  200.4    0.0    0.0    0.0  118.5  121.9
18 11 76 323   7 2200 10.0   59.0   48.8    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
18 11 76 323   8 2200 10.0   80.0   25.3    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
18 11 76 323   9 2200 10.0   39.9    0.0    0.0    0.0    0.0  134.7    0.0    0.0    0.0    0.0
18 11 76 323  10 2200 10.0   64.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
18 11 76 323  11 2200 10.0   21.9    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
18 11 76 323  12 2200 10.0   15.6    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
18 11 76 323  14 2200 10.0   15.8    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
11
19 11 76 324   2 1000 10.0   15.6    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
19 11 76 324   3 1000 10.0   15.5    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
19 11 76 324   4 1000 10.0   16.1    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
19 11 76 324   5 1000 10.0   18.8    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
19 11 76 324   6 1000 10.0   15.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
19 11 76 324   8 1000 10.0  254.9  296.5  192.6  170.4  110.0  377.0    0.0    0.0  146.4  151.1
19 11 76 324  10 1000 10.0   16.9    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
19 11 76 324  11 1000 10.0   15.6    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
19 11 76 324  12 1000 10.0   15.9    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
19 11 76 324  13 1000 10.0   17.3    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
19 11 76 324  14 1000 10.0   15.8    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0    0.0
```

266

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MM DD YY JDY REC HR  SHRS      OBS     PUFF2    PLUME   MSPUFF    RTM2     RADM     ****     ****    PUFF1    ARM3
 9
19 11 76 324  2 2200 10.0      15.8      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
19 11 76 324  3 2200 10.0      15.3      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
19 11 76 324  4 2200 10.0      15.1      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
19 11 76 324  5 2200 10.0      15.1      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
19 11 76 324  9 2200 10.0      26.8      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
19 11 76 324 11 2200 10.0      15.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
19 11 76 324 12 2200 10.0      15.2      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
19 11 76 324 13 2200 10.0      15.2      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
19 11 76 324 14 2200 10.0      15.6      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 6
 2  2 77  33  2 1000 10.0      17.7      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 2  2 77  33  3 1200  9.9      15.6      0.0     20.8      0.0    261.1      0.0      0.0      0.0      8.9      0.0
 2  2 77  33  4 1000 10.0      15.7      0.0      0.0      0.0      0.4      0.0      0.0      0.0      0.0      0.0
 2  2 77  33  5 1000 10.0      15.6      0.0     38.8      0.0     15.2      0.0      0.0      0.0      0.2      0.0
 2  2 77  33 11 1000 10.0      15.8      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 2  2 77  33 14 1000 10.0     117.7    157.9      0.0      0.0      0.1    285.8      0.0      0.0      0.0    145.7
 6
 2  2 77  33  2 2200 10.0      28.8      1.8      0.0      0.0      0.0      0.0      0.0      0.0      0.0      4.0
 2  2 77  33  4 2200 10.0      15.6      0.0      0.0      0.0      6.9      0.0      0.0      0.0      0.0      0.0
 2  2 77  33  5 2200 10.0      16.0      0.0     99.8      0.0      3.9      0.0      0.0      0.0      0.0      0.0
 2  2 77  33 11 2200 10.0      15.9     16.9     56.4      0.0     66.4      0.0      0.0      0.0     26.8     37.3
 2  2 77  33 13 2145 10.0      21.9      4.7      0.0      0.0      3.8      0.0      0.0      0.0      0.1     10.2
 2  2 77  33 14 2200 10.0      17.4     17.4     18.4      0.0    125.7     11.4      0.0      0.0      8.5     37.6
 7
 3  2 77  34  2 1000 10.0      17.2      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 3  2 77  34  3 1000 10.0      16.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 3  2 77  34  4 1000 10.0      15.6      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 3  2 77  34  5 1000 10.0      15.6      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 3  2 77  34 11 1000 10.0      15.6     20.0    852.9      0.0    592.8      0.0      0.0      0.0   1453.8      0.0
 3  2 77  34 13 1000 10.0      15.8      2.5    339.9      0.0    507.6      0.0      0.0      0.0    751.8      0.0
 3  2 77  34 14 1000 10.0     433.6      0.0      0.0      0.0      1.7   1195.4      0.0      0.0      0.0    652.2
 6
 3  2 77  34  2 2200 10.0      18.3      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 3  2 77  34  3 2200 10.0      16.1      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 3  2 77  34  4 2200 10.0      15.5      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 3  2 77  34  5 2200 10.0      15.6      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 3  2 77  34 13 2145 10.0      98.4      1.1      0.0      0.0      0.0    152.1      0.0      0.0      0.0      0.0
 3  2 77  34 14 2200 10.0      87.2      0.0      0.0      0.0      0.0    390.0      0.0      0.0      0.0      0.0
11
16  2 77  47  2 2200 10.0      15.8      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
16  2 77  47  3 2200 10.0      15.5      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
16  2 77  47  4 2200 10.0      15.7      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
16  2 77  47  5 2200 10.0      15.6      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
16  2 77  47  6 2200 10.0      51.5      0.0    520.5      0.0    651.1      0.0      0.0      0.0    426.7      0.0
16  2 77  47  7 2200 10.0      15.4      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
16  2 77  47  9 2200 10.0      15.2      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
16  2 77  47 11 2200 10.0      16.1      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
16  2 77  47 12 2200 10.0      15.7      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
16  2 77  47 13 2145 10.0      15.3      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
16  2 77  47 14 2200 10.0      15.6      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
```

```
MM DD YY JDY REC HR   SHRS       OBS     PUFF2    PLUME   MSPUFF    RTM2    RADM    ****    ****   PUFF1    ARM3
 12
17  2 77  48  2 1000 11.0       15.9      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0
17  2 77  48  3 1000 10.0       15.5      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0
17  2 77  48  4 1000 10.0       15.6      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0
17  2 77  48  5 1000 10.0       72.0      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0
17  2 77  48  6 1000 10.0       54.0     18.7    129.3      0.0     82.3  1119.5     0.0     0.0     0.0     0.0
17  2 77  48  7 1000 10.0       15.9     27.5      0.0      0.0      0.0     0.0     0.0     0.0    57.9   169.6
17  2 77  48  8 1000 10.0       25.1     12.6      0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0
17  2 77  48  9 1000 10.0       16.0      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0
17  2 77  48 10 1000 10.0       15.7      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0
17  2 77  48 12 1000 10.0       15.7      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0
17  2 77  48 13  945 10.0       15.8      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0
17  2 77  48 14 1000 10.0       15.9      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0
 11
17  2 77  48  2 2200 10.0       17.3      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0
17  2 77  48  3 2200 10.0       18.2      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0
17  2 77  48  4 2200 10.0       15.4      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0
17  2 77  48  6 2200 10.0       39.8      0.0      0.0      0.0      0.5     0.0     0.0     0.0     0.0     0.0
17  2 77  48  7 2200 10.0      259.9      8.7     21.8      3.2     12.0    22.6     0.0     0.0    13.3     2.6
17  2 77  48  9 2200 10.0       31.9      7.7      0.0      0.0      0.0   147.0     0.0     0.0     0.0    17.6
17  2 77  48 10 2200 10.0       16.8      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0
17  2 77  48 11 2200 10.0       16.6      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0
17  2 77  48 12 2200 10.0       15.5      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0
17  2 77  48 13 2200 10.0       15.8      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0
17  2 77  48 14 2200 10.0       15.5      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0
 12
18  2 77  49  2 1000 10.0       15.6      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0
18  2 77  49  3 1000 10.0       15.3      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0
18  2 77  49  4 1000 10.0       15.3      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0
18  2 77  49  5 1000 10.0       15.6      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0
18  2 77  49  6 1000 10.0       23.3      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0
18  2 77  49  7 1000 10.0       49.2    193.6      0.0    465.9      0.0     0.0     0.0     0.0     0.0     0.0
18  2 77  49  8 1000 10.0       25.5    179.9      0.0   2171.1     78.4    56.6     0.0     0.0     0.0     0.0
18  2 77  49  9 1000 10.0      142.5     20.5   1089.9      0.0    613.3   431.9     0.0     0.0  1602.9  1325.8
18  2 77  49 10 1000 10.0      165.1     49.9      0.0      0.0     55.9    92.1     0.0     0.0     0.0     0.0
18  2 77  49 11 1000 10.0      258.3    176.0      0.0      0.0      0.5    29.5     0.0     0.0     0.0     0.0
18  2 77  49 12 1000 10.0       15.7      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0
18  2 77  49 14 1000 10.0       15.5      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0
  7
18  2 77  49  2 2200 10.0       18.4      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0
18  2 77  49  6 2200 10.0       15.2      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0
18  2 77  49  7 2200 10.0       17.3    203.1      0.0      0.0      0.0   209.9     0.0     0.0     0.0    63.1
18  2 77  49  8 2200 10.0       16.3    313.4      0.0    491.3     34.3   282.1     0.0     0.0     0.0    97.1
18  2 77  49  9 2200 10.0       49.9      0.0     34.2      0.0     77.7     0.0     0.0     0.0    13.6     0.0
18  2 77  49 10 2200 10.0      123.9      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0
18  2 77  49 14 2200 10.0       15.1      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0
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MM DD YY JDY REC HR  SHRS      OBS     PUFF2    PLUME   MSPUFF    RTM2     RADM    ****    ****   PUFF1    ARM3
 13
22  2 77  53  2 1000 10.0     18.2      0.0      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0
22  2 77  53  3 1000 10.0     15.3      0.0      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0
22  2 77  53  4 1000 10.0     15.3      0.0      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0
22  2 77  53  5 1000 10.0     15.4      0.0      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0
22  2 77  53  6 1000 10.0     15.3      0.0      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0
22  2 77  53  7 1000 10.0     48.2      2.8      0.0      0.1     22.4      8.4     0.0     0.0     0.0     0.0
22  2 77  53  8 1000 10.0     40.8      0.0      2.8      0.0     26.0      0.0     0.0     0.0     0.0     0.0
22  2 77  53  9 1000  8.0     22.7     11.0      7.1      0.0     16.3     59.9     0.0     0.0     0.0     0.0
22  2 77  53 10 1000 10.0    308.1     43.9      0.0      0.0      0.8   2077.2     0.0     0.0     5.3   421.2
22  2 77  53 11 1000 10.0    677.2      0.0      0.0      0.0      0.0    328.6     0.0     0.0     0.0     0.0
22  2 77  53 12 1000 10.0     15.4      0.0      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0
22  2 77  53 13  945 10.0     62.9      0.0      0.0      0.0      0.0      2.8     0.0     0.0     0.0     0.0
22  2 77  53 14 1000 10.0     15.8      0.0      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0
 12
22  2 77  53  2 2200 10.0     15.8      0.0      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0
22  2 77  53  3 2200 10.0     15.3      0.0      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0
22  2 77  53  5 2200 10.0     15.3      0.0      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0
22  2 77  53  6 2200 10.0     15.3      0.0      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0
22  2 77  53  7 2200 10.0     15.6      0.0      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0
22  2 77  53  8 2200 10.0     15.5      0.0      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0
22  2 77  53  9 2000 10.0     15.3      0.0      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0
22  2 77  53 10 2200 10.0     23.9      0.0      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0
22  2 77  53 11 2200 10.0     19.5      0.0      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0
22  2 77  53 12 2200 10.0     15.3      0.0      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0
22  2 77  53 13 2145 10.0     16.9      0.0      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0
22  2 77  53 14 2200 10.0     15.5      0.0      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0
 8
 5  4 77  95  3 2200 10.0     15.9      0.0      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0
 5  4 77  95  4 2200 10.0     16.0      0.0      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0
 5  4 77  95  5 2200 10.0     16.8      0.0      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0
 5  4 77  95  8 2200 10.0     18.2      0.0      0.0      0.0      6.4      0.0     0.0     0.0     0.0     0.0
 5  4 77  95 11 2200 10.0     16.0      0.0      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0
 5  4 77  95 12 2200 34.0     15.8      0.0      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0
 5  4 77  95 13 2115 10.0     15.8      0.0      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0
 5  4 77  95 14 2200 10.0     16.1      0.0      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0
10
 6  4 77  96  2 1000 10.0     15.8      0.0      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0
 6  4 77  96  4 1000 10.0     15.9      0.0      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0
 6  4 77  96  5 1000 10.0     15.9      0.0      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0
 6  4 77  96  6 1000 10.0     15.9      0.0      0.0      0.0      0.3      0.0     0.0     0.0     0.0     0.5
 6  4 77  96  7 1000 10.0    200.1      0.0      0.0      0.0      1.0      0.0     0.0     0.0     0.0     1.4
 6  4 77  96  8 1000 10.0    631.5      8.4      0.0      0.0      0.5      0.0     0.0     0.0     0.0     0.7
 6  4 77  96 10 1000 10.0     16.1      0.0      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0
 6  4 77  96 11 1000 10.0     15.7      0.0      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0
 6  4 77  96 13  915 10.0     15.7      0.0      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0
 6  4 77  96 14 1400  6.0     15.7      0.0      0.0      0.0      0.0      0.0     0.0     0.0     0.0     0.0
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MM DD YY JDY REC HR   SHRS     OBS     PUFF2    PLUME   MSPUFF    RTM2     RADM     ****     ****    PUFF1     ARM3
  8
 6  4 77  96  3 2200 10.0     15.5      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 6  4 77  96  4 2200 10.0     15.5      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 6  4 77  96  6 2200 10.0     15.6    119.3      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 6  4 77  96  7 2200 10.0    143.7      0.0      0.0      0.0      0.0   1132.1      0.0      0.0      0.0      0.0
 6  4 77  96  8 2200 10.0    172.9      0.0      0.0      0.0     23.5      0.0      0.0      0.0      4.1    257.3
 6  4 77  96 10 2200 10.0     15.7      0.0      0.0      0.0     10.3      0.0      0.0      0.0      0.0      0.0
 6  4 77  96 13 2115 10.0     15.6      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 6  4 77  96 14 2200 10.0     15.6      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
12
 7  4 77  97  2 1000 10.0     15.3      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 7  4 77  97  3 1000 10.0     15.5      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 7  4 77  97  4 1000 10.0     15.4      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 7  4 77  97  6 1000 10.0     18.2      0.0     42.6      4.5     18.9     31.2      0.0      0.0     38.8     82.8
 7  4 77  97  7 1000 10.0     65.6      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 7  4 77  97  8 1000 10.0     33.8      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 7  4 77  97  9 1000 10.0     16.6      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 7  4 77  97 10 1000 10.0     55.7    101.1      0.0      0.0      0.0    191.4      0.0      0.0      0.0      0.0
 7  4 77  97 11 1000 10.0     24.3      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 7  4 77  97 12 1000 10.0     15.6      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 7  4 77  97 13  915 10.0     15.8      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 7  4 77  97 14 1000 10.0     15.5      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
  7
 7  4 77  97  3 2200 10.0     15.2      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 7  4 77  97  4 2200 10.0     15.4      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 7  4 77  97  5 2200 10.0     15.8      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 7  4 77  97 10 2200 10.0    162.6      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 7  4 77  97 12 2200 10.0     15.3      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 7  4 77  97 13 2115 10.0     35.8     15.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      3.0
 7  4 77  97 14 2200 10.0     15.2      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
10
 8  4 77  98  2 1000 10.0     15.2      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 8  4 77  98  3 1000 10.0     15.2      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 8  4 77  98  4 1000 10.0     14.9      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 8  4 77  98  5 1000 10.0     15.8      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 8  4 77  98  6 1000 10.0     14.9    239.9      0.0     16.0      0.0      0.0      0.0      0.0      0.0      0.0
 8  4 77  98  7 1000 10.0     34.2      0.0      0.0      0.0      0.1    226.6      0.0      0.0      0.0      0.0
 8  4 77  98  9 1000 10.0     68.7      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 3  4 77  98 10 1000 10.0     52.6      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 8  4 77  98 12 1000 10.0     15.2      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 8  4 77  98 14 1000 10.0     15.2      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
  6
 8  4 77  98  3 2200 10.0     14.6      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 8  4 77  98  4 2200 10.0     15.4      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 8  4 77  98  8 2200 10.0     68.1      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 8  4 77  98  9 2200 10.0     15.3      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 8  4 77  98 10 2200 10.0     15.4      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 8  4 77  98 12 2200 10.0     15.5      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
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MM DD YY JDY REC HR   SHRS      OBS      PUFF2     PLUME    MSPUFF      RTM2      RADM      ****      ****     PUFF1      ARM3
 13
11  4 77 101  2 1000 10.0      15.3        0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
11  4 77 101  3 1000 10.0      15.4        0.0       0.0       0.0     475.3       0.0       0.0       0.0      11.2       0.0
11  4 77 101  4 1000 10.0      16.2        0.0       0.0       0.0      76.2       0.0       0.0       0.0       0.0       0.0
11  4 77 101  5 1000 10.0      20.5        0.0       0.0       0.0     192.7       0.0       0.0       0.0       0.0       0.0
11  4 77 101  6 1000 10.0      16.0        0.0       0.0       0.0       2.8       0.0       0.0       0.0       1.1       0.0
11  4 77 101  7 1000 10.0      15.4        1.5       0.0       0.0       1.5       0.0       0.0       0.0       0.0       0.0
11  4 77 101  8 1000 10.0      25.6     2359.6       0.0       0.0     144.8     187.2       0.0       0.0       4.5     279.0
11  4 77 101  9 1000 10.0     295.9       52.4       0.0       0.0       0.1     251.5       0.0       0.0       0.0     365.2
11  4 77 101 10 1000 10.0     198.8     1183.5       0.0       0.0       0.0      63.7       0.0       0.0       0.0      92.9
11  4 77 101 11 1000 10.0      46.6       42.6       0.0       0.0       0.0     304.1       0.0       0.0       0.0     457.6
11  4 77 101 12 1000 10.0      15.1        0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
11  4 77 101 13  915 10.0     146.5        0.1       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
11  4 77 101 14 1000 10.0      15.3       57.9       0.0       0.0      27.0       0.0       0.0       0.0       0.0       0.0
 10
11  4 77 101  2 2200 10.0      15.8        4.5       0.0       0.0     187.1       0.0       0.0       0.0      33.4     215.9
11  4 77 101  5 2200 10.0      15.4        0.7      45.0       0.0      41.5       0.0       0.0       0.0      17.7      47.8
11  4 77 101  6 2200 10.0      15.5        0.7       0.0       0.0      14.2       0.0       0.0       0.0       7.5      16.7
11  4 77 101  8 2200 10.0      16.7      767.1       0.0       0.0      48.4      84.1       0.0       0.0       2.7      57.1
11  4 77 101  9 2200 10.0      55.3      142.6       0.0       0.0       1.1    1502.9       0.0       0.0       0.0       1.2
11  4 77 101 10 2200 10.0      57.4      375.7       0.0       0.0      44.5      69.6       0.0       0.0       0.2      50.8
11  4 77 101 11 2200 10.0      93.6      136.5       0.0       0.0       0.0      39.8       0.0       0.0       0.0       0.0
11  4 77 101 12 2200 10.0      15.3       13.3       0.0       0.0       2.0       0.0       0.0       0.0       0.0       2.3
11  4 77 101 13 2115 10.0      60.3       23.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
11  4 77 101 14 2200 10.0      15.3       44.8    2476.8       0.0     537.7       0.0       0.0       0.0     209.8     617.9
  9
12  4 77 102  3 1000 10.0      16.6       38.1     152.2       0.0     370.6       0.0       0.0       0.0     209.2     310.0
12  4 77 102  4 1000 10.0      16.1        6.7     792.5       0.0     179.3       0.0       0.0       0.0     262.2     382.3
12  4 77 102  5 1000 10.0      15.9       14.4       3.2       0.0      47.6       0.0       0.0       0.0      83.3     119.0
12  4 77 102  6 1000 10.0      15.4       22.4       0.0       0.0      12.0       0.0       0.0       0.0       5.4       8.0
12  4 77 102  7 1000 10.0      17.4       83.1       0.0       0.0      26.3       0.0       0.0       0.0       2.8       4.1
12  4 77 102  9 1000 10.0      16.9      109.1       0.0       0.0      33.1       0.0       0.0       0.0       1.8       2.5
12  4 77 102 11 1000 10.0      18.8       67.3       0.0       0.0       0.0     264.1       0.0       0.0       0.0       0.0
12  4 77 102 12 1000 10.0      15.3       19.6       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
12  4 77 102 13  915 10.0      31.9       20.3       0.0       0.0       0.0     175.7       0.0       0.0       0.0       0.0
  8
12  4 77 102  3 2200 10.0      19.2       51.6       4.5       0.0      10.3       0.0       0.0       0.0       9.6      13.2
12  4 77 102  4 2200 10.0      19.3       20.6      17.7       0.0       5.3       0.0       0.0       0.0      11.3       5.4
12  4 77 102  6 2200 10.0      15.4       17.0       0.0       0.0       0.0       0.0       0.0       0.0       0.1       4.3
12  4 77 102  7 2200 10.0      17.0       40.9       0.0       0.0       0.0       0.0       0.0       0.0       0.3      10.8
12  4 77 102 10 2200 10.0      16.8      145.3       0.0       0.0      19.2       0.0       0.0       0.0      21.8      37.4
12  4 77 102 11 2200 10.0      17.3       70.0       0.0       0.0       2.3     245.5       0.0       0.0       4.1      18.4
12  4 77 102 13 2115 10.0      18.1       23.3       0.0       0.0       0.0     225.0       0.0       0.0       0.1       6.0
12  4 77 102 14 2200 10.0      18.0     1833.2      26.6       0.0    1401.8      20.2       0.0       0.0     339.7     461.8
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MM DD YY JDY REC HR   SHRS     OBS    PUFF2   PLUME  MSPUFF    RTM2    RADM    ****    ****   PUFF1    ARM3
 10
13  4 77 103  2 1000 10.0     17.8   137.3    34.5     0.0   140.6     0.0     0.0     0.0    14.4     5.2
13  4 77 103  3 1000 10.0     17.4    43.8     5.6     0.0     0.0     0.0     0.0     0.0     4.2     1.4
13  4 77 103  4 1000 10.0     16.8    35.9     0.6     0.0     0.0     0.0     0.0     0.0     2.1     0.7
13  4 77 103  5 1000 10.0     18.1    21.8     0.8     0.0     0.0     0.0     0.0     0.0     1.1     0.4
13  4 77 103  6 1000 10.0     15.4     8.6     0.7     0.0     0.0     0.0     0.0     0.0     0.2     0.1
13  4 77 103  7 1000 10.0     16.8    10.6     1.2     0.0     0.0     0.0     0.0     0.0     1.2     0.5
13  4 77 103  8 1000 10.0     16.8    26.0     3.8     0.0     0.0     0.0     0.0     0.0     5.1     1.8
13  4 77 103 11 1000 10.0    154.5    24.5     0.0     0.0     0.0     0.0     0.0     0.0     9.6     3.4
13  4 77 103 13  915 10.0     81.5     9.9     0.0     0.0     0.0   243.6     0.0     0.0     2.9     1.1
13  4 77 103 14 1000 10.0     18.1   136.2  1252.9     0.2   451.4     0.0     0.0     0.0  2837.9   997.8
  9
13  4 77 103  2 2200 10.0     18.1    51.5     0.0    71.1    15.1     0.0     0.0     0.0     1.8    72.5
13  4 77 103  3 2200 10.0     16.4    16.3     0.0     0.0     0.0     0.0     0.0     0.0     0.4    23.3
13  4 77 103  4 2200 10.0     15.6    12.7     0.0     0.0     0.0     0.0     0.0     0.0     0.2    17.9
13  4 77 103  6 2200 10.0     15.1     4.6     0.0     0.0     0.0     0.0     0.0     0.0     0.0     6.6
13  4 77 103  7 2200 10.0     17.0     7.9     0.3     0.0     0.0     0.0     0.0     0.0     0.2    11.2
13  4 77 103  9 2200 10.0     16.6    14.5     1.0     0.0     0.0     0.0     0.0     0.0     0.7    21.1
13  4 77 103 12 2200 10.0     25.5    89.1   174.8    45.8   130.9     0.0     0.0     0.0   201.9   127.9
13  4 77 103 13 2115 10.0     20.8    13.5     0.0     0.0     0.0   155.6     0.0     0.0     1.3    19.7
13  4 77 103 14 2200 10.0     34.6    45.9     0.9     5.4    21.7     0.0     0.0     0.0     1.5    65.9
 12
14  4 77 104  3 1000 10.0     15.2     8.8     0.0     2.8     0.0     0.0     0.0     0.0     0.0     0.0
14  4 77 104  4 1300  7.0     15.7     7.3     0.0     1.0     0.0     0.0     0.0     0.0     0.0     0.0
14  4 77 104  5 1000 10.0     14.7     5.0     0.0     0.2     0.0     0.0     0.0     0.0     0.0     0.0
14  4 77 104  6 1000 10.0     15.0     3.1     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
14  4 77 104  7 1000  6.0     15.2     5.3     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
14  4 77 104  8 1000 10.0     15.3     9.0     0.0     1.0     0.0     0.0     0.0     0.0     0.0     0.0
14  4 77 104  9 1000 10.0     15.8     9.4     0.0     0.2     0.0     0.0     0.0     0.0     0.1     0.0
14  4 77 104 10 1000 10.0     16.8    16.0     0.0    11.0     0.0     4.7     0.0     0.0     0.0    14.4
14  4 77 104 11 1000 10.0     17.2    14.8     0.0     1.5     0.7     0.6     0.0     0.0     2.6     1.8
14  4 77 104 12 1000 10.0     17.2    58.4     0.0    47.5     4.8     0.0     0.0     0.0     1.1     0.0
14  4 77 104 13  915 10.0     18.4    10.5     0.0     0.0     1.0     0.0     0.0     0.0     3.9     0.0
14  4 77 104 14 1000 10.0     15.9    22.0     0.0    36.8     0.0     0.0     0.0     0.0     0.0     0.0
 11
14  4 77 104  2 2200 10.0     17.5    27.7     0.0    16.8     0.0     0.0     0.0     0.0     0.0   160.2
14  4 77 104  4 2200 10.0     14.9     0.1     0.0     0.6     0.0     0.0     0.0     0.0     0.0     0.6
14  4 77 104  5 2200 10.0     21.1     0.0     0.0     0.1     0.0     0.0     0.0     0.0     0.0     0.0
14  4 77 104  6 2200 10.0     15.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
14  4 77 104  7 2200 10.0     15.4     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
14  4 77 104  8 2200 10.0     16.6     0.2     0.0     0.9     0.0     0.0     0.0     0.0     0.0     1.2
14  4 77 104 10 2200 10.0    355.6     2.4     0.0     5.7     5.9    73.7     0.0     0.0     0.0    14.0
14  4 77 104 11 2200 10.0     20.9     1.3     0.0     3.0     0.0   178.8     0.0     0.0     0.4     7.8
14  4 77 104 12 2200 10.0     18.2    49.7     0.0    30.6     0.0     0.0     0.0     0.0     0.0   292.7
14  4 77 104 13 2115 10.0     17.9     0.5     0.0     0.6     6.9     0.0     0.0     0.0     2.8     2.9
14  4 77 104 14 2200 10.0     17.5     7.7     0.0  1282.4     2.4     0.0     0.0     0.0     0.0    45.2
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MM DD YY JDY REC HR   SHRS       OBS      PUFF2     PLUME    MSPUFF      RTM2       RADM      ****      ****     PUFF1      ARM3
 12
15  4 77 105  3 1000 10.0       17.7        3.5       0.0       1.6       0.3        0.0       0.0       0.0       0.0       0.0
15  4 77 105  4 1000 10.0       15.3        2.5       0.0       2.2       0.0        0.0       0.0       0.0       0.0       0.0
15  4 77 105  5 1000 10.0       15.3        0.9       0.0       0.6       0.0        0.0       0.0       0.0       0.0       0.0
15  4 77 105  6 1000 10.0       15.4        0.2       0.0       0.3       0.0        0.0       0.0       0.0       0.0       0.0
15  4 77 105  7 1000 10.0      112.3        0.4      25.1       0.9      25.3        0.0       0.0       0.0      37.5       0.0
15  4 77 105  8 1000 10.0      136.5        6.1     320.5       2.2     226.7     2546.1       0.0       0.0     607.4     353.4
15  4 77 105  9 1000 10.0      158.8        1.3       0.0       2.4       5.8        0.0       0.0       0.0       0.0       0.0
15  4 77 105 10 1000 10.0       34.0        6.4       0.0       5.3      14.0     1890.6       0.0       0.0       0.0     259.2
15  4 77 105 11 1000 10.0       46.5        3.3       0.0       4.9       0.0      263.2       0.0       0.0       0.0      35.0
15  4 77 105 12 1000 10.0       16.5       26.7       0.0      12.3       0.0        0.0       0.0       0.0       0.0       0.0
15  4 77 105 13  915 10.0       14.5        1.0       0.0       2.8       0.0       11.0       0.0       0.0       0.0       1.6
15  4 77 105 14 1000 10.0       16.1       13.3       0.0       5.3       0.9        0.0       0.0       0.0       0.0       0.0
 10
15  4 77 105  3 2200 10.0       15.4        8.0       0.0       8.1      27.8        0.0       0.0       0.0       0.0       0.0
15  4 77 105  4 2200 10.0       16.2        6.1       0.0      11.3       1.2        0.0       0.0       0.0       0.0       0.0
15  4 77 105  6 2200 10.0       15.1        5.2       0.0       1.3       1.5        0.0       0.0       0.0       0.0       0.0
15  4 77 105  8 2200 10.0       42.6       43.7     108.7       3.9      87.8     1295.1       0.0       0.0      14.4     213.5
15  4 77 105  9 2200 10.0       25.1        4.9       0.1       5.0       3.4       21.6       0.0       0.0       0.0       0.0
15  4 77 105 10 2200 10.0       17.1       11.6       0.0       5.2       0.3        0.0       0.0       0.0       0.0       0.0
15  4 77 105 11 2200 10.0       15.5        7.0       0.0       6.0       0.0      193.6       0.0       0.0       0.0       0.0
15  4 77 105 12 2200 10.0       15.3       16.6       0.0       4.5       0.0        0.0       0.0       0.0       0.0       0.0
15  4 77 105 13 2115 10.0       15.7        3.2       0.0       5.6       0.0      137.5       0.0       0.0       0.0       0.0
15  4 77 105 14 2200 10.0       36.2       15.3       0.0      13.3      13.4      565.7       0.0       0.0       0.0       0.0
  1
17  4 77 107 14 2200 10.0     1055.9      145.5       0.0       0.0      65.8    46384.1       0.0       0.0       0.0       0.0
 11
18  4 77 108  2 1000 10.0       79.4      458.7       0.0       0.7       0.9     1268.7       0.0       0.0       0.0     497.5
18  4 77 108  3 1000 10.0       16.1       74.9       0.0     154.0       0.0        0.0       0.0       0.0       0.0      83.4
18  4 77 108  4 1000 10.0       15.9       15.2       0.0      13.5       0.0        0.0       0.0       0.0       0.0      17.2
18  4 77 108  5 1000 10.0       17.1        0.1       0.0     157.5       0.0        0.0       0.0       0.0       0.0       0.1
18  4 77 108  6 1000 10.0       15.7        0.0       0.0     190.5       0.0        0.0       0.0       0.0       0.0       0.0
18  4 77 108  7 1000 10.0       19.5        0.0       0.0      48.1       0.0        0.0       0.0       0.0       0.6       0.0
18  4 77 108  8 1000 10.0       18.6        0.0       7.2     169.8       0.3        0.0       0.0       0.0       4.7       0.0
18  4 77 108  9 1000 10.0       16.6        0.0     148.5      20.2      24.6        0.0       0.0       0.0      52.5       0.0
18  4 77 108 11 1000 22.0       18.5        0.0     371.0       5.5     126.6        0.0       0.0       0.0     111.0       0.0
18  4 77 108 12 1000 10.0       85.2        0.9       0.0       0.0       3.3        0.0       0.0       0.0       0.0       1.0
18  4 77 108 13  915 12.0       15.5        0.0     303.6       0.0      93.6        0.0       0.0       0.0     115.6       0.0
  6
18  4 77 108  2 2200 10.0       18.1      330.3       0.0       5.3       0.0       76.6       0.0       0.0       0.0       0.0
18  4 77 108  3 2200 10.0       15.8        2.1       0.0      17.0       0.0        0.0       0.0       0.0       0.0       0.0
18  4 77 108  4 2200 10.0       15.7        3.8       0.0       2.6       0.0        0.0       0.0       0.0       0.0       0.0
18  4 77 108  5 2200 10.0       16.9        0.0       0.0       9.5       0.0        0.0       0.0       0.0       0.0       0.0
18  4 77 108 10 2200 10.0       15.9        0.0       0.0     209.5      78.7        0.0       0.0       0.0       0.0       0.0
18  4 77 108 13 2115 10.0       17.7        0.0       0.0      85.8       0.4        0.0       0.0       0.0       0.0       0.0
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MM DD YY JDY REC HR   SHRS     OBS    PUFF2   PLUME  MSPUFF    RTM2    RADM    ****    ****   PUFF1    ARM3
 11
19  4 77 109  2 1000  10.0    16.1     0.0     0.0     0.1     0.0    16.4     0.0     0.0     0.0     0.0
19  4 77 109  3 1000  10.0    15.4     0.0     0.0     0.3     0.0     0.0     0.0     0.0     0.0     0.0
19  4 77 109  5 1000  10.0    15.4     0.0     0.0     0.1     0.0     0.0     0.0     0.0     0.0     0.0
19  4 77 109  7 1000  10.0    15.5     0.0     0.0   112.7     0.0     0.0     0.0     0.0     0.0     0.0
19  4 77 109  8 1000  10.0    16.1   544.7     0.0   349.8     9.4  1119.2     0.0     0.0     0.0   935.4
19  4 77 109  9 1000  10.0   107.2   174.3     8.0   777.6   118.3    22.4     0.0     0.0     0.0   301.4
19  4 77 109 10 1000  10.0   145.4   174.0  3298.5   582.2  1044.9   716.2     0.0     0.0   248.5   301.9
19  4 77 109 11 1000  27.0    30.0   221.9  1603.2   405.5   355.3     0.0     0.0     0.0   479.3   370.7
19  4 77 109 12 1000  10.0    21.2   144.0     0.0     1.0     0.0     0.0     0.0     0.0     0.0   242.6
19  4 77 109 13  915  10.0   279.6     0.0   866.9   166.3   620.9     0.0     0.0     0.0  1012.5     0.0
19  4 77 109 14 1000  10.0    15.9     0.0     0.0     1.1     0.6     0.0     0.0     0.0     0.0     0.0
  9
19  4 77 109  2 2200  10.0    17.2     5.6     0.0     1.3     0.0     0.0     0.0     0.0     0.0     0.6
19  4 77 109  3 2200  10.0    15.7     0.0     0.0     1.4     0.0     0.0     0.0     0.0     0.0     0.6
19  4 77 109  4 2200  10.0    15.6     0.0     0.0     0.6     0.0     0.0     0.0     0.0     0.0     0.2
19  4 77 109  7 2200  10.0    15.5     0.3     0.0    51.4     0.0     0.0     0.0     0.0     0.0    21.4
19  4 77 109  8 2200  10.0    16.5    68.7     0.0   102.2     0.0   116.6     0.0     0.0     0.0    42.2
19  4 77 109  9 2200  10.0    17.4   740.7     0.0   401.8     0.2    34.4     0.0     0.0     0.0   161.3
19  4 77 109 12 2200  10.0    17.7   125.8     0.0    62.6     0.0     0.0     0.0     0.0     0.0    25.3
19  4 77 109 13 2115  10.0    25.4   122.8   115.9   166.5   108.9     0.0     0.0     0.0   161.8    67.7
19  4 77 109 14 2200  10.0    17.6    12.2     0.0  1037.8     5.3   104.4     0.0     0.0     0.0   429.7
 12
20  4 77 110  2 1000  10.0    15.8     5.4     0.0  2327.2     3.0     0.0     0.0     0.0     0.0   371.6
20  4 77 110  3 1000  10.0    15.7     0.0     0.0    14.2     0.0     0.0     0.0     0.0     0.0     2.2
20  4 77 110  4 1000  10.0    15.7     0.0     0.0     7.7     0.0     0.0     0.0     0.0     0.0     1.2
20  4 77 110  5 1000  10.0    15.5     0.0     0.0     4.8     0.0     0.0     0.0     0.0     0.0     0.7
20  4 77 110  6 1000  10.0    15.3     0.0     0.0     3.1     0.0     0.0     0.0     0.0     0.0     0.5
20  4 77 110  7 1000  10.0    15.6     0.3     0.0     6.1     0.0     0.0     0.0     0.0     0.0     1.0
20  4 77 110  8 1000  10.0    16.0     7.8     0.0    16.8     0.0     0.0     0.0     0.0     0.0     2.6
20  4 77 110  9 1000  10.0    16.3    25.8     0.0    15.5     0.0   320.0     0.0     0.0     0.0     2.4
20  4 77 110 10 1000  10.0  1452.2   107.8     0.0    52.2     0.0   166.9     0.0     0.0     0.0     8.3
20  4 77 110 12 1000  10.0    16.2   137.7   142.4   148.0    28.6   140.4     0.0     0.0     6.8    22.8
20  4 77 110 13  915  10.0    16.8    46.9     0.0    13.0     2.8     0.0     0.0     0.0     0.0     2.0
20  4 77 110 14 1000  10.0    25.6   197.5     0.0  3581.6  2153.5     0.0     0.0     0.0     0.0   568.9
  9
20  4 77 110  2 2200  10.0    16.5     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
20  4 77 110  3 2200  10.0    15.3     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
20  4 77 110  4 2200  10.0    15.6     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
20  4 77 110  6 2200  10.0    16.3     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
20  4 77 110  7 2200  10.0    15.8     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
20  4 77 110  9 2200  10.0    15.6     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
20  4 77 110 11 2200  10.0    17.8     0.0     0.0     0.0     0.0   149.0     0.0     0.0     0.0     0.0
20  4 77 110 12 2200  10.0    87.6   373.3     0.0    47.3    15.8  1405.9     0.0     0.0     2.5     0.0
20  4 77 110 13 2115  10.0    25.0     0.0     0.0     0.0     0.0     4.5     0.0     0.0     0.0     0.0
```

```
MM DD YY JDY REC HR   SHRS     OBS    PUFF2   PLUME  MSPUFF    RTM2    RADM    ****    ****   PUFF1    ARM3
 13
21  4 77 111  2 1000 10.0     15.4     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
21  4 77 111  3 1000 10.0     15.3     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
21  4 77 111  4 1000 10.0     17.9     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
21  4 77 111  5 1000 10.0     15.2     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
21  4 77 111  6 1000 10.0     15.2     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
21  4 77 111  7 1000 10.0     15.4     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
21  4 77 111  8  920 10.0     15.5     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
21  4 77 111  9 1000 10.0     15.3     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
21  4 77 111 10 1000 10.0     16.1     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
21  4 77 111 11 1000 10.0     15.2     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
21  4 77 111 12 1000 10.0     18.1   797.1  1207.9    85.5   567.9  2380.9     0.0     0.0   557.4  1102.3
21  4 77 111 13  915 10.0     16.5     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
21  4 77 111 14 1000 10.0    797.2     0.0     0.0     0.0   196.8    83.1     0.0     0.0     0.0     0.0
 10
21  4 77 111  2 2200 10.0     15.3     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
21  4 77 111  3 2200 10.0     16.9     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
21  4 77 111  6 2200 10.0     15.2     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
21  4 77 111  7 2200 10.0     15.4     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
21  4 77 111  8 2200 10.0     15.3     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
21  4 77 111  9 2200 10.0     15.2     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
21  4 77 111 10 2200 10.0     15.2     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
21  4 77 111 12 2200 10.0     15.7    47.1     2.4   149.3    12.6     0.0     0.0     0.0     5.5    30.5
21  4 77 111 13 2115 10.0     15.5     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
21  4 77 111 14 2200 10.0     19.8     0.0     0.0     0.0   177.7     0.0     0.0     0.0     0.0     0.0
 12
22  4 77 112  2 1000 10.0     15.2     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
22  4 77 112  3 1000 10.0     15.3     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
22  4 77 112  4 1000 10.0     15.2     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
22  4 77 112  5 1000 10.0     16.3     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
22  4 77 112  6 1000 10.0     15.2     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
22  4 77 112  7 1000 10.0     15.6     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
22  4 77 112  8 1000 10.0     15.2     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
22  4 77 112  9 1000 10.0     15.2     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
22  4 77 112 11 1000 10.0     15.2     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
22  4 77 112 12 1000 10.0     62.2    18.4     8.4     0.0    24.7   230.6     0.0     0.0     0.0     5.4
22  4 77 112 13  915 10.0     15.1     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
22  4 77 112 14 1000 10.0   1168.3   165.2     0.0     0.0     2.1   190.5     0.0     0.0     0.0    50.0
 13
27  4 77 117  2  900 10.0     15.7     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
27  4 77 117  3  900 12.0     15.7     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
27  4 77 117  4  900 10.0     15.9     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
27  4 77 117  5  830 10.0     15.6     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
27  4 77 117  6  900 10.0     15.9    18.8     0.1     8.9    96.5    63.6     0.0     0.0     0.0    28.3
27  4 77 117  7  900 10.0     83.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
27  4 77 117  8  900 22.0     26.8     0.0     0.0     0.0     6.1     0.0     0.0     0.0     1.2     0.0
27  4 77 117  9  900 10.0     15.9     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
27  4 77 117 10  900 10.0     15.6     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
27  4 77 117 11  900 10.0     15.9     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
27  4 77 117 12  900 10.0     15.7     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
27  4 77 117 13  815 10.0     15.9     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
27  4 77 117 14  900 10.0     15.9     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
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MM DD YY JDY REC HR   SHRS     OBS    PUFF2    PLUME   MSPUFF    RTM2    RADM    ****    ****   PUFF1    ARM3
  9
18  7 77 199  2 2100  10.0    15.1     0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0
18  7 77 199  3 2100  10.0    15.0     0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0
18  7 77 199  4 2100  10.0    15.4     0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0
18  7 77 199  7 2100  10.0    15.0     0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0
18  7 77 199  9 2100  10.0    15.3     0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0
18  7 77 199 10 2100  10.0    15.0     0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0
18  7 77 199 12 2100  10.0    15.2     0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0
18  7 77 199 13 2030  10.0    33.2     0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0
18  7 77 199 14 2100  10.0    15.0     0.0      0.0      0.0     0.7     0.0     0.0     0.0     0.0     0.0
 11
19  7 77 200  2  900  10.0    15.0     0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0
19  7 77 200  3  900  10.0    15.0     0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0
19  7 77 200  5  900  10.0    14.9     0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0
19  7 77 200  7  900  10.0    15.2     0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0
19  7 77 200  8  900  10.0    18.1     0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0
19  7 77 200  9  900  10.0    15.4     0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0
19  7 77 200 10  900  10.0  2275.6     0.0      0.0      0.0    12.8     0.0     0.0     0.0     0.0     0.0
19  7 77 200 11  900  10.0  1525.1     0.0      0.0      0.0     0.7     0.0     0.0     0.0     0.0     0.0
19  7 77 200 12  900  10.0    15.1     0.0      0.8    605.9    86.5     0.0     0.0     0.0     0.0     0.0
19  7 77 200 13  830  12.0    15.4     0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0
19  7 77 200 14  900  10.0    15.0     0.0      0.0      0.0   153.2     0.0     0.0     0.0     0.0     0.0
  6
19  7 77 200  2 2100  10.0    14.9     0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0
19  7 77 200  3 2100  10.0    15.0     0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0
19  7 77 200  4 2100  10.0    15.2     0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0
19  7 77 200  5 2100  10.0    15.2     0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0
19  7 77 200 10 2100  10.0    82.4    80.6      0.0      0.0    48.5   180.9     0.0     0.0     0.0     0.0
19  7 77 200 14 2100  10.0    15.0     0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0
 10
20  7 77 201  3  900  10.0    15.9     0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0
20  7 77 201  5  900  10.0    15.1     0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0
20  7 77 201  7  900  10.0    15.0     0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0
20  7 77 201  8  900  10.0    15.3     0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0
20  7 77 201  9  900   5.0    16.1     0.0      0.0      0.0    53.8     0.0     0.0     0.0     0.0     0.0
20  7 77 201 10  900  10.0    20.0     0.0      0.0      0.0    71.5     0.0     0.0     0.0     0.0     0.0
20  7 77 201 11  900   8.5    18.2    46.9    717.5      0.0   292.0     2.5     0.0     0.0   291.0   175.7
20  7 77 201 12  900  10.0    15.6     0.0      0.0      0.4     0.0     0.0     0.0     0.0     0.0     0.0
20  7 77 201 13  830  10.0    22.8    36.1    178.0      0.0    85.4     0.0     0.0     0.0    47.4    44.8
20  7 77 201 14  900   9.3    15.0     0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0
 10
25  7 77 206  3  900  10.0    15.9     0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0
25  7 77 206  4  900  10.0    15.9     0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0
25  7 77 206  5  900  10.0    15.7     0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0
25  7 77 206  7  900  10.0    16.0     0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0
25  7 77 206  8  900  10.0    15.9     0.0      0.0    549.1     0.0     0.0     0.0     0.0     0.0     0.0
25  7 77 206 10  900  10.0   381.9     0.5   2294.7      0.0   807.7    68.0     0.0     0.0  5308.8  1999.7
25  7 77 206 11  900  10.0   104.6     0.0    447.9      0.0   209.1     6.3     0.0     0.0   787.0     0.0
25  7 77 206 12  900  10.0    16.7     0.0      0.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0
25  7 77 206 13  830  10.0   169.4     0.0    112.9      0.0    54.7     0.0     0.0     0.0   151.6     0.0
25  7 77 206 14  900  10.0    15.8     0.0      0.0      0.0     1.7     0.0     0.0     0.0     0.0     0.0
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MM DD YY JDY REC HR   SHRS      OBS      PUFF2     PLUME    MSPUFF     RTM2      RADM      ****      ****     PUFF1     ARM3
 8
27  4 77 117  2 2100 10.0      15.6       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
27  4 77 117  3 2345 10.0      15.6       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
27  4 77 117  6 2100 10.0      15.7       6.1       0.0       0.0       0.0      13.9       0.0       0.0       0.0       0.0
27  4 77 117  9 2100 10.0      41.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
27  4 77 117 10 2100 10.0      18.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
27  4 77 117 11 2100 10.0      16.2       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
27  4 77 117 12 2100 10.0      15.6       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
27  4 77 117 14 2100 10.0      15.5       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 10
28  4 77 118  2 1200  7.0      15.4       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
28  4 77 118  4  900 10.0      15.6       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
28  4 77 118  5  900 10.0      18.3       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
28  4 77 118  6  900 10.0      15.5       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
28  4 77 118  7  900 10.0     427.4       0.0     320.5     825.8     256.4       0.0       0.0       0.0     282.2       0.0
28  4 77 118  8  900 10.0    1573.6       0.0     312.2     169.9     175.5       0.0       0.0       0.0     249.9       0.0
28  4 77 118  9  900 10.0     132.5       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
28  4 77 118 10  900 10.0      15.6       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
28  4 77 118 12  900 10.0      15.6       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
28  4 77 118 13  815 10.0      15.5       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 12
28  4 77 118  2 2100 10.0      18.3       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
28  4 77 118  3 2100 10.0      17.2       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
28  4 77 118  4 2100 10.0      15.5       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
28  4 77 118  5 2100 10.0      15.9       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
28  4 77 118  6 2100 10.0      15.6       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
28  4 77 118  7 2100 10.0      28.6     178.7       0.0      32.4       3.5     413.8       0.0       0.0       0.5       0.0
28  4 77 118  8 2100 10.0      29.4     115.4      24.6     122.3      27.0     232.1       0.0       0.0      38.6     111.1
28  4 77 118  9 2100 10.0      71.2       0.0      21.5       0.0      65.8       0.0       0.0       0.0      35.3      95.6
28  4 77 118 11 2100 10.0      15.4       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
28  4 77 118 12 2100 10.0      15.4       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
28  4 77 118 13 2015 10.0      17.6       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
28 14 77 118 14 2100 10.0      15.4       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 12
11  7 77 192  2  900 10.0      15.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
11  7 77 192  3  900 10.0      14.9       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
11  7 77 192  4  900 10.0      14.7       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
11  7 77 192  5  900 10.0      14.8       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
11  7 77 192  7  900 10.0      18.9      84.7     644.8       0.0     462.9       0.0       0.0       0.0       0.0       0.0
11  7 77 192  8  900 10.0      31.1    2064.6     484.7       0.0     711.4       0.0       0.0       0.0    1106.1       0.0
11  7 77 192  9  900 10.0     127.3    1452.5       0.0       0.3     229.9       0.0       0.0       0.0     777.6       0.0
11  7 77 192 10  900 10.0      43.4       0.0       0.0    2347.3       0.2       0.0       0.0       0.0       0.2       0.1
11  7 77 192 11  900 10.0      15.0       0.0       0.0     213.1       5.5       0.0       0.0       0.0       0.0    1341.4
11  7 77 192 12  900 10.0      14.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0     122.6
11  7 77 192 13  830 10.0      15.0       0.0       0.0      19.6      16.7       0.0       0.0       0.0       1.0       0.0
11  7 77 192 14  900 10.0      15.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0      11.5
                                                                                                              0.0       0.0
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MM DD YY JDY REC HR   SHRS     OBS    PUFF2   PLUME  MSPUFF    RTM2    RADM    ****    ****   PUFF1    ARM3
 11
11  7 77 192  2 2100  10.0    14.9     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
11  7 77 192  3 2100  10.0    15.2     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
11  7 77 192  5 2100  10.0    17.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
11 17 77 192  6 1600  15.0    14.9     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
11  7 77 192  7 2100  10.0    15.5    79.9     0.7     0.0     9.2  1168.6     0.0     0.0     0.4     0.0
11  7 77 192  8 2100  10.0    15.0   444.2     1.3    17.0     8.3   175.6     0.0     0.0     0.0    24.1
11  7 77 192  9 2100  10.0    18.5   256.0    17.8   198.2    31.9     0.0     0.0     0.0    64.3   275.6
11  7 77 192 11 2100  10.0    22.4    73.8     4.0    90.7    29.8     0.0     0.0     0.0    38.1   126.8
11  7 77 192 12 2100  10.0    14.9     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
11  7 77 192 13 2045  10.0    45.2    42.2    55.3    24.9    32.4     0.0     0.0     0.0    85.7    34.9
11  7 77 192 14 2100  10.0    14.8     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 11
15  7 77 196  2  900  10.0    16.5     2.0     0.2     0.0     0.0     0.0     0.0     0.0     0.0     0.0
15  7 77 196  3  900  10.0    15.6     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
15  7 77 196  4  900  10.0    15.6     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
15  7 77 196  5  900  10.0    15.4     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
15  7 77 196  7  900  10.0    15.9     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
15  7 77 196  9  900  10.0    15.8     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
15  7 77 196 10  900  10.0   239.1     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
15  7 77 196 11  900  10.0    28.2     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
15  7 77 196 12  900  10.0    18.7     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
15  7 77 196 13  845  10.0    15.9     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
15  7 77 196 14  900  10.0    42.5    15.9     0.4     0.0     2.0    21.6     0.0     0.0     0.0     0.0
  9
15  7 77 196  2 2200  10.0    16.0     7.4     5.7     0.0    27.9     0.0     0.0     0.0    16.1     0.0
15  7 77 196  3 2100  10.0    16.2     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
15  7 77 196  4 2100  10.0    15.9     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
15  7 77 196  7 2100  10.0    25.5     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
15  7 77 196  8 2100  10.0    15.9     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
15  7 77 196 10 2100  10.0    18.4     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
15  7 77 196 11 2100  10.0    16.5     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
15  7 77 196 12 2100  10.0    22.5     0.4     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
15  7 77 196 14 2100  10.0    17.5     0.0     6.3     0.0     1.0    18.2     0.0     0.0     7.9     0.0
 12
18  7 77 199  2  900  10.0    15.2     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
18  7 77 199  3  900  10.0    15.1     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
18  7 77 199  4  900  10.0    15.2     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
18  7 77 199  5  900  10.0    15.2     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
18  7 77 199  7  900  10.0    15.2     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
18  7 77 199  8  900  10.0    15.4     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
18  7 77 199  9  900  10.0    15.2     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
18  7 77 199 10  900  10.0    15.3     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
18  7 77 199 11 1200   7.0    15.1     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
18  7 77 199 12  900  10.0    15.9     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
18  7 77 199 13 1300   5.8    16.1     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
18  7 77 199 14  900  10.0    36.1     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
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MM DD YY JDY REC HR   SHRS       OBS      PUFF2     PLUME    MSPUFF      RTM2      RADM      ****      ****     PUFF1      ARM3
 9
25  7 77 206  3 2100 10.0       15.9       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
25  7 77 206  4 2100 10.0       18.1       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
25  7 77 206  7 2100 10.0       16.0       0.0       0.0    1199.4       0.0       0.0       0.0       0.0       0.0       0.0
25  7 77 206  8 2100 10.0       15.8       0.0       0.0     263.5       0.1       0.0       0.0       0.0       0.0       0.0
25  7 77 206  9 2100 10.0       18.7     431.4     504.7       0.0     305.5     834.4       0.0       0.0     323.5     529.3
25  7 77 206 10 2100 10.0       29.7      73.4      17.2       0.0       3.8     173.0       0.0       0.0       2.9      90.2
25  7 77 206 11 2100 10.0       31.1     141.1      14.3       0.0      33.2     117.2       0.0       0.0       2.8     172.4
25  7 77 206 12 2100 10.0       15.4       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
25  7 77 206 14 2100 10.0       25.6       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 10
26  7 77 207  3  900 10.0       15.6       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
26  7 77 207  4  900 10.0       15.6       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
26  7 77 207  5  900 10.0       15.9       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
26  7 77 207  7  900 10.0       15.6       0.0       0.0      81.8       5.3       0.0       0.0       0.0       0.0       0.0
26  7 77 207  8  900 10.0       15.7       0.0      28.5     200.6      60.4       0.0       0.0       0.0      24.6       0.0
26  7 77 207  9  900 10.0       15.7      14.3       0.3       0.0      22.7       0.0       0.0       0.0       0.0       3.4
26  7 77 207 10  900 10.0       71.7      29.4       0.0       0.0       0.1       2.1       0.0       0.0       0.0       7.0
26  7 77 207 11  900 10.0       75.2     113.8       0.0       0.0       0.0     472.3       0.0       0.0       0.0      27.1
26  7 77 207 12  900 10.0       14.9       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
26  7 77 207 13  830 10.0       54.5     512.6       0.0       0.0       0.0     113.7       0.0       0.0       0.0     118.1
 11
26  7 77 207  3 2100 10.0       15.3       0.0       0.0       0.0       0.0      19.2       0.0       0.0       0.0       0.0
26  7 77 207  4 2100 10.0       15.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
26  7 77 207  5 2100 10.0       16.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
26  7 77 207  7 2100 10.0       15.4      12.1       0.0       0.0       0.0       0.0       0.0       0.0       0.0       6.0
26  7 77 207  8 2100 10.0       17.0      17.7       0.0       0.0       3.7     285.1       0.0       0.0       0.0       8.6
26  7 77 207  9 2100 10.0       19.8     127.5      31.2       0.0      14.4     186.1       0.0       0.0      17.4      62.2
26  7 77 207 10 2100 10.0       19.9      28.4       0.0       0.0       7.3       0.0       0.0       0.0       0.0      13.6
26  7 77 207 11 2100 10.0       20.1     118.4       0.0       0.0       1.7     123.1       0.0       0.0       0.0      56.2
26  7 77 207 12 2100 10.0       30.2       2.4       0.0       0.0       0.0       0.0       0.0       0.0       0.0       1.2
26  7 77 207 13 2030 10.0       19.0     148.1       0.0       0.0       0.5     547.7       0.0       0.0       0.0      70.8
26  7 77 207 14 2100 10.0       16.5       1.2       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.6
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DD MM YY JDY REC HR   SHRS    OBS    PUFF2   PLUME  MSPUFF    RTM2    RADM  ****  ****   PUFF1   ARM3
 7
 5 10 76 279  2 2200  14.0   188.8   237.3   159.5     0.0   294.9     7.7   0.0   0.0   190.2  332.9
 5 10 76 279  5 2200  14.0    17.0     0.0     0.0     0.0     0.0     0.0   0.0   0.0     0.0    0.0
 5 10 76 279  6 2200  14.0    17.4     0.0     0.0     0.0     0.0     0.0   0.0   0.0     0.0    0.0
 5 10 76 279 10 2200  14.0    15.5    19.7     0.0   156.7     0.0     0.0   0.0   0.0     0.0    0.0
 5 10 76 279 11 2200  14.0    15.1    16.8     0.0   504.9     0.0     0.0   0.0   0.0     0.0    0.0
 5 10 76 279 12 2200  14.0   376.0    85.9   156.0   129.3   280.1     0.0   0.0   0.0    97.7  174.6
 5 10 76 279 14 2200  14.0   675.9    24.7   389.2     0.0  1756.4  4530.5   0.0   0.0   509.9  880.9
12
14 10 76 288  2 2200  15.0    16.7     0.0     0.0     0.0     0.0     0.0   0.0   0.0     0.0    0.0
14 10 76 288  3 2300  13.0    18.0     0.0     0.0     0.0     0.0     0.0   0.0   0.0     0.0    0.0
14 10 76 288  4 2200  14.0    14.9     0.0     0.0     0.0     0.0     0.0   0.0   0.0     0.0    0.0
14 10 76 288  5 2200  14.0    15.3     0.0     0.0     0.0     0.0     0.0   0.0   0.0     0.0    0.0
14 10 76 288  6 2200  14.0    16.9    21.4     0.0     0.0    76.4     0.0   0.0   0.0     4.0    0.0
14 10 76 288  7 2200  15.0    15.6   614.5     0.0   262.5   312.1     0.0   0.0   0.0   277.8  111.8
14 10 76 288  9 2200  14.0    15.6     0.0   388.3     0.0   338.1     0.0   0.0   0.0  1321.7  272.5
14 10 76 288 10 2200  13.0    47.6     0.0   923.8     0.0    12.5     0.0   0.0   0.0     0.0    0.0
14 10 76 288 11 2155  14.0    15.2     0.0     0.0     0.0     0.1     0.0   0.0   0.0     0.0    0.0
14 10 76 288 12 2200  14.0    15.4     0.0     0.0     0.0     0.0     0.0   0.0   0.0     0.0    0.0
14 10 76 288 13 2100  15.0    15.3     0.0     0.0     0.0     0.2     0.0   0.0   0.0     0.3    0.0
14 10 76 288 14 2225  14.0    15.3     0.0     0.0     0.0     0.0     0.0   0.0   0.0     0.0    0.0
 11
15 10 76 289  2 1300   8.0    15.3     0.0     0.0     0.0     0.0     0.0   0.0   0.0     0.0    0.0
15 10 76 289  3 1200   7.0    15.8     0.0     0.0     0.0     0.0     0.0   0.0   0.0     0.0    0.0
15 10 76 289  4 1300   8.0    17.1     0.0     0.0     0.0     0.0     0.0   0.0   0.0     0.0    0.0
15 10 76 289  5 1300   8.0    20.2     2.6     0.0     0.0     0.0     0.0   0.0   0.0     0.0    2.0
15 10 76 289  6 1300   8.0    15.5     3.2     0.0     0.0     0.0     0.0   0.0   0.0     0.0    2.5
15 10 76 289  7 1300   8.0    17.0     0.0     0.0     0.0     0.6     0.0   0.0   0.0     0.0    0.0
15 10 76 289  8 1345   7.3    49.0   456.5     0.0   176.3    62.5     0.0   0.0   0.0     0.0  350.4
15 10 76 289  9 1300   7.9    44.4     0.0   309.9     0.0   230.6     0.0   0.0   0.0  1128.4    0.0
15 10 76 289 10 1200   9.0    36.6     0.0     0.0     0.0    17.7     0.0   0.0   0.0     0.0    0.0
15 10 76 289 12 1300   8.0    15.9     0.0     0.0     0.0     0.0     0.0   0.0   0.0     0.0    0.0
15 10 76 289 13 1315   7.2    17.6     0.0    39.0     0.0    12.3     0.0   0.0   0.0     2.3    0.0
 1
15 10 76 289  9 2200  14.0   191.4   154.5     0.0     0.0   766.0     0.0   0.0   0.0     0.0    0.0
 9
29 10 76 303  2  900  10.0   194.7     0.0    22.1    17.1    29.6     0.0   0.0   0.0     4.4    6.8
29 10 76 303  3  900  10.0    16.0     0.0     0.0     0.0     0.0     0.0   0.0   0.0     0.0    0.0
29 10 76 303  4  900  10.0    16.2     0.0     0.0     0.0     0.0     0.0   0.0   0.0     0.0    0.0
29 10 76 303  5  900  10.0    15.9     0.0     0.0     0.0     0.0     0.0   0.0   0.0     0.0    0.0
29 10 76 303  6  900  10.0    15.6     0.0     0.0     0.0     0.0     0.0   0.0   0.0     0.0    0.0
20 10 76 303  7  900  10.0    15.6     0.0     0.0     0.0     0.0     0.0   0.0   0.0     0.0    0.0
29 10 76 303  9  900  10.0    15.8     0.0     0.0     0.0     0.0     0.0   0.0   0.0     0.0    0.0
29 10 76 303 10  900  10.0    15.7     0.0     0.0     0.0     0.0     0.0   0.0   0.0     0.0    0.0
29 10 76 303 14  900  10.0   347.0     0.0   245.7   212.6    54.2     0.0   0.0   0.0   146.9   76.3
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DD MM YY JDY REC HR   SHRS    OBS   PUFF2  PLUME  MSPUFF   RTM2   RADM   ****   ****  PUFF1   ARM3
  8
29 10 76 303  2 2100 10.0   157.6    0.1    3.7     0.0   30.6    0.0    0.0    0.0    2.0    0.7
29 10 76 303  3 2100 10.0    18.4    0.0    0.0     0.0    0.0    0.0    0.0    0.0    0.0    0.0
29 10 76 303  4 2100 10.0    15.7    0.0    0.0     0.0    0.0    0.0    0.0    0.0    0.0    0.0
29 10 76 303  5 2100 10.0    35.0    0.0    0.0     0.0    0.0    0.0    0.0    0.0    0.0    0.0
29 10 76 303  6 2100 10.0    15.8    0.0    0.0     0.0    0.0    0.0    0.0    0.0    0.0    0.0
29 10 76 303 10 2100 10.0    15.8    0.0    0.0     0.0    0.0    0.0    0.0    0.0    0.0    0.0
 9 10 76 303 12 2100 10.0    15.6   15.3   70.5    87.9   41.5    0.0    0.0    0.0   64.2   25.8
 9 10 76 303 14 2100 10.0   242.5   24.5    0.0     0.0   57.1    0.0    0.0    0.0    0.0    0.0
 11
 8 11 76 323  2 1000 10.0    17.1    0.0    0.0     0.0    0.0    0.0    0.0    0.0    0.0    0.0
 8 11 76 323  3 1000 10.0    23.9    0.0    0.0     0.0    0.0    0.0    0.0    0.0    0.0    0.0
 8 11 76 323  4 1000 10.0    17.9    0.0    0.0     0.0    0.0    0.0    0.0    0.0    0.0    0.0
 8 11 76 323  6 1000 10.0    26.2    0.0    0.0     0.0    1.2    0.0    0.0    0.0    0.0    0.0
 8 11 76 323  7 1000 10.0    20.3    0.0    0.0     0.0    0.0    0.0    0.0    0.0    0.0    0.0
 8 11 76 323  8 1000 10.0    19.6    0.0    0.0     0.0    0.0    0.0    0.0    0.0    0.0    0.0
 8 11 76 323 10 1000 10.0    17.2    0.0    0.0     0.0    0.0    0.0    0.0    0.0    0.0    0.0
 8 11 76 323 11 1430  5.5    15.9    0.0    0.0     0.0    0.0    0.0    0.0    0.0    0.0    0.0
 8 11 76 323 12 1000 10.0    16.1    0.0    0.0     0.0    0.0    0.0    0.0    0.0    0.0    0.0
 8 11 76 323 13 1000 10.0    16.1    0.0    0.0     0.0    0.0    0.0    0.0    0.0    0.0    0.0
 8 11 76 323 14 1000 10.0    17.3    0.0    0.0     0.0    0.0    0.0    0.0    0.0    0.0    0.0
 12
 3 11 76 323  2 2200 10.0    15.7    0.0    0.0     0.0    0.0    0.0    0.0    0.0    0.0    0.0
 3 11 76 323  3 2200 10.0    15.8    0.0    0.0     0.0    0.0    0.0    0.0    0.0    0.0    0.0
 3 11 76 323  4 2200 10.0    15.8    0.0    0.0     0.0    0.0    0.0    0.0    0.0    0.0    0.0
   11 76 323  5 2200 10.0    16.0    0.0    0.0     0.0    0.0    0.0    0.0    0.0    0.0    0.0
 3 11 76 323  6 2200 10.0    16.6    0.0    1.1   140.4  200.4    0.0    0.0    0.0  118.5  121.9
 3 11 76 323  7 2200 10.0    59.0   48.8    0.0     0.0    0.0    0.0    0.0    0.0    0.0    0.0
   11 76 323  8 2200 10.0    80.0   25.3    0.0     0.0    0.0  134.7    0.0    0.0    0.0    0.0
   11 76 323  9 2200 10.0    39.9    0.0    0.0     0.0    0.0    0.0    0.0    0.0    0.0    0.0
   11 76 323 10 2200 10.0    64.0    0.0    0.0     0.0    0.0    0.0    0.0    0.0    0.0    0.0
   11 76 323 11 2200 10.0    21.9    0.0    0.0     0.0    0.0    0.0    0.0    0.0    0.0    0.0
   11 76 323 12 2200 10.0    15.6    0.0    0.0     0.0    0.0    0.0    0.0    0.0    0.0    0.0
   11 76 323 14 2200 10.0    15.8    0.0    0.0     0.0    0.0    0.0    0.0    0.0    0.0    0.0
 1
   11 76 324  2 1000 10.0    15.6    0.0    0.0     0.0    0.0    0.0    0.0    0.0    0.0    0.0
   11 76 324  3 1000 10.0    15.5    0.0    0.0     0.0    0.0    0.0    0.0    0.0    0.0    0.0
   11 76 324  4 1000 10.0    16.1    0.0    0.0     0.0    0.0    0.0    0.0    0.0    0.0    0.0
   11 76 324  5 1000 10.0    18.8    0.0    0.0     0.0    0.0    0.0    0.0    0.0    0.0    0.0
   11 76 324  6 1000 10.0    15.0    0.0    0.0     0.0    0.0    0.0    0.0    0.0    0.0    0.0
   11 76 324  8 1000 10.0   254.9  296.5  192.6   170.4  110.0  377.0    0.0    0.0  146.4  151.1
   11 76 324 10 1000 10.0    16.9    0.0    0.0     0.0    0.0    0.0    0.0    0.0    0.0    0.0
   11 76 324 11 1000 10.0    15.6    0.0    0.0     0.0    0.0    0.0    0.0    0.0    0.0    0.0
   11 76 324 12 1000 10.0    15.9    0.0    0.0     0.0    0.0    0.0    0.0    0.0    0.0    0.0
   11 76 324 13 1000 10.0    17.3    0.0    0.0     0.0    0.0    0.0    0.0    0.0    0.0    0.0
   11 76 324 14 1000 10.0    15.8    0.0    0.0     0.0    0.0    0.0    0.0    0.0    0.0    0.0
```

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DD MM YY JDY REC HR   SHRS      OBS   PUFF2   PLUME  MSPUFF    RTM2    RADM    ****    ****   PUFF1    ARM3
  9
19 11 76 324  2 2200  10.0     15.8     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
19 11 76 324  3 2200  10.0     15.3     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
19 11 76 324  4 2200  10.0     15.1     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
19 11 76 324  5 2200  10.0     15.1     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
19 11 76 324  9 2200  10.0     26.8     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
19 11 76 324 11 2200  10.0     15.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
19 11 76 324 12 2200  10.0     15.2     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
19 11 76 324 13 2200  10.0     15.2     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
19 11 76 324 14 2200  10.0     15.6     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
  6
 2  2 77  33  2 1000  10.0     17.7     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 2  2 77  33  3 1200   9.9     15.6     0.0    20.8     0.0   261.1     0.0     0.0     0.0     8.9     0.0
 2  2 77  33  4 1000  10.0     15.7     0.0     0.0     0.0     0.4     0.0     0.0     0.0     0.0     0.0
 2  2 77  33  5 1000  10.0     15.6     0.0    38.8     0.0    15.2     0.0     0.0     0.0     0.2     0.0
 2  2 77  33 11 1000  10.0     15.8     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 2  2 77  33 14 1000  10.0    117.7   157.9     0.0     0.0     0.1   285.8     0.0     0.0     0.0   145.7
  6
 2  2 77  33  2 2200  10.0     28.8     1.8     0.0     0.0     0.0     0.0     0.0     0.0     0.0     4.0
 2  2 77  33  4 2200  10.0     15.6     0.0     0.0     0.0     6.9     0.0     0.0     0.0     0.0     0.0
 2  2 77  33  5 2200  10.0     16.0     0.0    99.8     0.0     3.9     0.0     0.0     0.0     0.0     0.0
 2  2 77  33 11 2200  10.0     15.9    16.9    56.4     0.0    66.4     0.0     0.0     0.0    26.8    37.3
 2  2 77  33 13 2145  10.0     21.9     4.7     0.0     0.0     3.8     0.0     0.0     0.0     0.1    10.2
 2  2 77  33 14 2200  10.0     17.4    17.4    18.4     0.0   125.7    11.4     0.0     0.0     8.5    37.6
  7
 3  2 77  34  2 1000  10.0     17.2     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 3  2 77  34  3 1000  10.0     16.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 3  2 77  34  4 1000  10.0     15.6     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 3  2 77  34  5 1000  10.0     15.6     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 3  2 77  34 11 1000  10.0     15.6    20.0   852.9     0.0   592.8     0.0     0.0     0.0  1453.8     0.0
 3  2 77  34 13 1000  10.0     15.8     2.5   339.9     0.0   507.6     0.0     0.0     0.0   751.8     0.0
 3  2 77  34 14 1000  10.0    433.6     0.0     0.0     0.0     1.7  1195.4     0.0     0.0     0.0   652.2
  6
 3  2 77  34  2 2200  10.0     18.3     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 3  2 77  34  3 2200  10.0     16.1     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 3  2 77  34  4 2200  10.0     15.5     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 3  2 77  34  5 2200  10.0     15.6     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 3  2 77  34 13 2145  10.0     98.4     1.1     0.0     0.0     0.0   152.1     0.0     0.0     0.0     0.0
 3  2 77  34 14 2200  10.0     87.2     0.0     0.0     0.0     0.0   390.0     0.0     0.0     0.0     0.0
 11
16  2 77  47  2 2200  10.0     15.8     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
16  2 77  47  3 2200  10.0     15.5     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
16  2 77  47  4 2200  10.0     15.7     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
16  2 77  47  5 2200  10.0     15.6     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
16  2 77  47  6 2200  10.0     51.5     0.0   520.5     0.0   651.1     0.0     0.0     0.0   426.7     0.0
16  2 77  47  7 2200  10.0     15.4     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
16  2 77  47  9 2200  10.0     15.2     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
16  2 77  47 11 2200  10.0     16.1     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
16  2 77  47 12 2200  10.0     15.7     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
16  2 77  47 13 2145  10.0     15.3     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
16  2 77  47 14 2200  10.0     15.6     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
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DD MM YY JDY REC HR   SHRS       OBS     PUFF2     PLUME    MSPUFF      RTM2      RADM      ****      ****     PUFF1      ARM3
 12
17  2 77  48   2 1000 11.0      15.9       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
17  2 77  48   3 1000 10.0      15.5       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
17  2 77  48   4 1000 10.0      15.6       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
17  2 77  48   5 1000 10.0      72.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
17  2 77  48   6 1000 10.0      54.0      18.7     129.3       0.0      82.3    1119.5       0.0       0.0      57.9     169.6
17  2 77  48   7 1000 10.0      15.9      27.5       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
17  2 77  48   8 1000 10.0      25.1      12.6       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
17  2 77  48   9 1000 10.0      16.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
17  2 77  48  10 1000 10.0      15.7       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
17  2 77  48  12 1000 10.0      15.7       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
17  2 77  48  13  945 10.0      15.8       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
17  2 77  48  14 1000 10.0      15.9       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 11
17  2 77  48   2 2200 10.0      17.3       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
17  2 77  48   3 2200 10.0      18.2       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
17  2 77  48   4 2200 10.0      15.4       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
17  2 77  48   6 2200 10.0      39.8       0.0       0.0       0.0       0.5       0.0       0.0       0.0       0.0       0.0
17  2 77  48   7 2200 10.0     259.9       8.7      21.8       3.2      12.0      22.6       0.0       0.0      13.3       2.6
17  2 77  48   9 2200 10.0      31.9       7.7       0.0       0.0       0.0     147.0       0.0       0.0       0.0      17.6
17  2 77  48  10 2200 10.0      16.8       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
17  2 77  48  11 2200 10.0      16.6       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
17  2 77  48  12 2200 10.0      15.5       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
17  2 77  48  13 2200 10.0      15.8       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
17  2 77  48  14 2200 10.0      15.5       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 12
18  2 77  49   2 1000 10.0      15.6       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
18  2 77  49   3 1000 10.0      15.3       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
18  2 77  49   4 1000 10.0      15.3       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
18  2 77  49   5 1000 10.0      15.6       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
18  2 77  49   6 1000 10.0      23.3       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
18  2 77  49   7 1000 10.0      49.2     193.6       0.0     465.9       0.0       0.0       0.0       0.0       0.0       0.0
18  2 77  49   8 1000 10.0      25.5     179.9       0.0    2171.1      78.4      56.6       0.0       0.0       0.0       0.0
18  2 77  49   9 1000 10.0     142.5      20.5    1089.9       0.0     613.3     431.9       0.0       0.0    1602.9    1325.8
18  2 77  49  10 1000 10.0     165.1      49.9       0.0       0.0      55.9      92.1       0.0       0.0       0.0       0.0
18  2 77  49  11 1000 10.0     258.3     176.0       0.0       0.0       0.5      29.5       0.0       0.0       0.0       0.0
18  2 77  49  12 1000 10.0      15.7       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
18  2 77  49  14 1000 10.0      15.5       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
  7
18  2 77  49   2 2200 10.0      18.4       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
18  2 77  49   6 2200 10.0      15.2       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
18  2 77  49   7 2200 10.0      17.3     203.1       0.0       0.0       0.0     209.9       0.0       0.0       0.0      63.1
18  2 77  49   8 2200 10.0      16.3     313.4       0.0     491.3      34.3     282.1       0.0       0.0       0.0      97.1
18  2 77  49   9 2200 10.0      49.9       0.0      34.2       0.0      77.7       0.0       0.0       0.0      13.6       0.0
18  2 77  49  10 2200 10.0     123.9       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
18  2 77  49  14 2200 10.0      15.1       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
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DD MM YY JDY REC HR   SHRS       OBS      PUFF2     PLUME    MSPUFF      RTM2      RADM      ****      ****     PUFF1      ARM3
 13
22  2 77  53  2 1000 10.0       18.2       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
22  2 77  53  3 1000 10.0       15.3       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
22  2 77  53  4 1000 10.0       15.3       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
22  2 77  53  5 1000 10.0       15.4       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
22  2 77  53  6 1000 10.0       15.3       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
22  2 77  53  7 1000 10.0       48.2       2.8       0.0       0.1      22.4       8.4       0.0       0.0       0.0       0.0
22  2 77  53  8 1000 10.0       40.8       0.0       2.8       0.0      26.0       0.0       0.0       0.0       0.0       0.0
22  2 77  53  9 1000  8.0       22.7      11.0       7.1       0.0      16.3      59.9       0.0       0.0       0.0       0.0
22  2 77  53 10 1000 10.0      308.1      43.9       0.0       0.0       0.8    2077.2       0.0       0.0       5.3     421.2
22  2 77  53 11 1000 10.0      677.2       0.0       0.0       0.0       0.0     328.6       0.0       0.0       0.0       0.0
22  2 77  53 12 1000 10.0       15.4       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
22  2 77  53 13  945 10.0       62.9       0.0       0.0       0.0       0.0       2.8       0.0       0.0       0.0       0.0
22  2 77  53 14 1000 10.0       15.8       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 12
22  2 77  53  2 2200 10.0       15.8       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
22  2 77  53  3 2200 10.0       15.3       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
22  2 77  53  5 2200 10.0       15.3       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
22  2 77  53  6 2200 10.0       15.3       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
22  2 77  53  7 2200 10.0       15.6       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
22  2 77  53  8 2200 10.0       15.5       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
22  2 77  53  9 2000 10.0       15.3       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
22  2 77  53 10 2200 10.0       23.9       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
22  2 77  53 11 2200 10.0       19.5       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
22  2 77  53 12 2200 10.0       15.3       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
22  2 77  53 13 2145 10.0       16.9       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
22  2 77  53 14 2200 10.0       15.5       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
  8
 5  4 77  95  3 2200 10.0       15.9       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 5  4 77  95  4 2200 10.0       16.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 5  4 77  95  5 2200 10.0       16.8       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 5  4 77  95  8 2200 10.0       18.2       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 5  4 77  95 11 2200 10.0       16.0       0.0       0.0       0.0       6.4       0.0       0.0       0.0       0.0       0.0
 5  4 77  95 12 2200 34.0       15.8       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 5  4 77  95 13 2115 10.0       15.8       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 5  4 77  95 14 2200 10.0       16.1       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 10
 6  4 77  96  2 1000 10.0       15.8       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 6  4 77  96  4 1000 10.0       15.9       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 6  4 77  96  5 1000 10.0       15.9       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 6  4 77  96  6 1000 10.0       15.9       0.0       0.0       0.0       0.3       0.0       0.0       0.0       0.0       0.0
 6  4 77  96  7 1000 10.0      200.1       0.0       0.0       0.0       1.0       0.0       0.0       0.0       0.0       0.5
 6  4 77  96  8 1000 10.0      631.5       8.4       0.0       0.0       0.5       0.0       0.0       0.0       0.0       1.4
 6  4 77  96 10 1000 10.0       16.1       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.7
 6  4 77  96 11 1000 10.0       15.7       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 6  4 77  96 13  915 10.0       15.7       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 6  4 77  96 14 1400  6.0       15.7       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
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DD MM  YY JDY REC HR   SHRS      OBS      PUFF2     PLUME    MSPUFF      RTM2      RADM      ****      ****     PUFF1      ARM3
 8
6   4  77  96   3 2200 10.0      15.5       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
6   4  77  96   4 2200 10.0      15.5       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
6   4  77  96   6 2200 10.0      15.6     119.3       0.0       0.0       0.0    1132.1       0.0       0.0       0.0       0.0
6   4  77  96   7 2200 10.0     143.7       0.0       0.0       0.0      23.5       0.0       0.0       0.0       4.1     257.3
6   4  77  96   8 2200 10.0     172.9       0.0       0.0       0.0      10.3       0.0       0.0       0.0       0.0       0.0
6   4  77  96  10 2200 10.0      15.7       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
6   4  77  96  13 2115 10.0      15.6       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
6   4  77  96  14 2200 10.0      15.6       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
12
7   4  77  97   2 1000 10.0      15.3       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
7   4  77  97   3 1000 10.0      15.5       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
7   4  77  97   4 1000 10.0      15.4       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
7   4  77  97   6 1000 10.0      18.2       0.0      42.6       4.5      18.9      31.2       0.0       0.0      38.8      82.8
7   4  77  97   7 1000 10.0      65.6       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
7   4  77  97   8 1000 10.0      33.8       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
7   4  77  97   9 1000 10.0      16.6       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
7   4  77  97  10 1000 10.0      55.7     101.1       0.0       0.0       0.0     191.4       0.0       0.0       0.0       0.0
7   4  77  97  11 1000 10.0      24.3       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
7   4  77  97  12 1000 10.0      15.6       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
7   4  77  97  13  915 10.0      15.8       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
7   4  77  97  14 1000 10.0      15.5       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 7
7   4  77  97   3 2200 10.0      15.2       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
7   4  77  97   4 2200 10.0      15.4       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
7   4  77  97   5 2200 10.0      15.8       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
7   4  77  97  10 2200 10.0     162.6       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
7   4  77  97  12 2200 10.0      15.3       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
7   4  77  97  13 2115 10.0      35.8      15.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       3.0
7   4  77  97  14 2200 10.0      15.2       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
10
8   4  77  98   2 1000 10.0      15.2       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
8   4  77  98   3 1000 10.0      15.2       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
8   4  77  98   4 1000 10.0      14.9       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
8   4  77  98   5 1000 10.0      15.8       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
8   4  77  98   6 1000 10.0      14.9       0.0       0.0      16.0       0.0       0.0       0.0       0.0       0.0       0.0
8   4  77  98   7 1000 10.0      34.2     239.9       0.0       0.0       0.1     226.6       0.0       0.0       0.0       0.0
8   4  77  98   9 1000 10.0      68.7       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
8   4  77  98  10 1000 10.0      52.6       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
8   4  77  98  12 1000 10.0      15.2       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
8   4  77  98  14 1000 10.0      15.2       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
 6
8   4  77  98   3 2200 10.0      14.6       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
8   4  77  98   4 2200 10.0      15.4       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
8   4  77  98   8 2200 10.0      68.1       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
8   4  77  98   9 2200 10.0      15.3       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
8   4  77  98  10 2200 10.0      15.4       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
8   4  77  98  12 2200 10.0      15.5       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
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DD MM YY JDY REC HR   SHRS     OBS    PUFF2    PLUME  MSPUFF    RTM2    RADM    ****    ****   PUFF1    ARM3
 13
11  4 77 101  2 1000  10.0    15.3      0.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
11  4 77 101  3 1000  10.0    15.4      0.0      0.0     0.0   475.3     0.0     0.0     0.0    11.2     0.0
11  4 77 101  4 1000  10.0    16.2      0.0      0.0     0.0    76.2     0.0     0.0     0.0     0.0     0.0
11  4 77 101  5 1000  10.0    20.5      0.0      0.0     0.0   192.7     0.0     0.0     0.0     0.0     0.0
11  4 77 101  6 1000  10.0    16.0      0.0      0.0     0.0     2.8     0.0     0.0     0.0     1.1     0.0
11  4 77 101  7 1000  10.0    15.4      1.5      0.0     0.0     1.5     0.0     0.0     0.0     0.0     0.0
11  4 77 101  8 1000  10.0    25.6   2359.6      0.0     0.0   144.8   187.2     0.0     0.0     4.5   279.0
11  4 77 101  9 1000  10.0   295.9     52.4      0.0     0.0     0.1   251.5     0.0     0.0     0.0   365.2
11  4 77 101 10 1000  10.0   198.8   1183.5      0.0     0.0     0.0    63.7     0.0     0.0     0.0    92.9
11  4 77 101 11 1000  10.0    46.6     42.6      0.0     0.0     0.0   304.1     0.0     0.0     0.0   457.6
11  4 77 101 12 1000  10.0    15.1      0.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
11  4 77 101 13  915  10.0   146.5      0.1      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
11  4 77 101 14 1000  10.0    15.3     57.9      0.0     0.0    27.0     0.0     0.0     0.0     0.0     0.0
 10
11  4 77 101  2 2200  10.0    15.8      4.5      0.0     0.0   187.1     0.0     0.0     0.0    33.4   215.9
11  4 77 101  5 2200  10.0    15.4      0.7     45.0     0.0    41.5     0.0     0.0     0.0    17.7    47.8
11  4 77 101  6 2200  10.0    15.5      0.7      0.0     0.0    14.2     0.0     0.0     0.0     7.5    16.7
11  4 77 101  8 2200  10.0    16.7    767.1      0.0     0.0    48.4    84.1     0.0     0.0     2.7    57.1
11  4 77 101  9 2200  10.0    55.3    142.6      0.0     0.0     1.1  1502.9     0.0     0.0     0.0     1.2
11  4 77 101 10 2200  10.0    57.4    375.7      0.0     0.0    44.5    69.6     0.0     0.0     0.2    50.8
11  4 77 101 11 2200  10.0    93.6    136.5      0.0     0.0     0.0    39.8     0.0     0.0     0.0     0.0
11  4 77 101 12 2200  10.0    15.3     13.3      0.0     0.0     2.0     0.0     0.0     0.0     0.0     2.3
11  4 77 101 13 2115  10.0    60.3     23.0      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
11  4 77 101 14 2200  10.0    15.3     44.8   2476.8     0.0   537.7     0.0     0.0     0.0   209.8   617.9
  9
12  4 77 102  3 1000  10.0    16.6     38.1    152.2     0.0   370.6     0.0     0.0     0.0   209.2   310.0
12  4 77 102  4 1000  10.0    16.1      6.7    792.5     0.0   179.3     0.0     0.0     0.0   262.2   382.3
12  4 77 102  5 1000  10.0    15.9     14.4      3.2     0.0    47.6     0.0     0.0     0.0    83.3   119.0
12  4 77 102  6 1000  10.0    15.4     22.4      0.0     0.0    12.0     0.0     0.0     0.0     5.4     8.0
12  4 77 102  7 1000  10.0    17.4     83.1      0.0     0.0    26.3     0.0     0.0     0.0     2.8     4.1
12  4 77 102  9 1000  10.0    16.9    109.1      0.0     0.0    33.1     0.0     0.0     0.0     1.8     2.5
12  4 77 102 11 1000  10.0    18.8     67.3      0.0     0.0     0.0   264.1     0.0     0.0     0.0     0.0
12  4 77 102 12 1000  10.0    15.3     19.6      0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
12  4 77 102 13  915  10.0    31.9     20.3      0.0     0.0     0.0   175.7     0.0     0.0     0.0     0.0
  8
12  4 77 102  3 2200  10.0    19.2     51.6      4.5     0.0    10.3     0.0     0.0     0.0     9.6    13.2
12  4 77 102  4 2200  10.0    19.3     20.6     17.7     0.0     5.3     0.0     0.0     0.0    11.3     5.4
12  4 77 102  6 2200  10.0    15.4     17.0      0.0     0.0     0.0     0.0     0.0     0.0     0.1     4.3
12  4 77 102  7 2200  10.0    17.0     40.9      0.0     0.0     0.0     0.0     0.0     0.0     0.3    10.8
12  4 77 102 10 2200  10.0    16.8    145.3      0.0     0.0    19.2     0.0     0.0     0.0    21.8    37.4
12  4 77 102 11 2200  10.0    17.3     70.0      0.0     0.0     2.3   245.5     0.0     0.0     4.1    18.4
12  4 77 102 13 2115  10.0    18.1     23.3      0.0     0.0     0.0   225.0     0.0     0.0     0.1     6.0
12  4 77 102 14 2200  10.0    18.0   1833.2     26.6     0.0  1401.8    20.2     0.0     0.0   339.7   461.8
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DD MM YY JDY REC HR   SHRS     OBS    PUFF2   PLUME   MSPUFF    RTM2     RADM    ****    ****    PUFF1    ARM3
 10
13  4 77 103  2 1000 10.0     17.8   137.3    34.5      0.0   140.6      0.0     0.0     0.0     14.4     5.2
13  4 77 103  3 1000 10.0     17.4    43.8     5.6      0.0     0.0      0.0     0.0     0.0      4.2     1.4
13  4 77 103  4 1000 10.0     16.8    35.9     0.6      0.0     0.0      0.0     0.0     0.0      2.1     0.7
13  4 77 103  5 1000 10.0     18.1    21.8     0.8      0.0     0.0      0.0     0.0     0.0      1.1     0.4
13  4 77 103  6 1000 10.0     15.4     8.6     0.7      0.0     0.0      0.0     0.0     0.0      0.2     0.1
13  4 77 103  7 1000 10.0     16.8    10.6     1.2      0.0     0.0      0.0     0.0     0.0      1.2     0.5
13  4 77 103  8 1000 10.0     16.8    26.0     3.8      0.0     0.0      0.0     0.0     0.0      5.1     1.8
13  4 77 103 11 1000 10.0    154.5    24.5     0.0      0.0     0.0      0.0     0.0     0.0      9.6     3.4
13  4 77 103 13  915 10.0     81.5     9.9     0.0      0.0     0.0    243.6     0.0     0.0      2.9     1.1
13  4 77 103 14 1000 10.0     18.1   136.2  1252.9      0.2   451.4      0.0     0.0     0.0   2837.9   997.8
  9
13  4 77 103  2 2200 10.0     18.1    51.5     0.0     71.1    15.1      0.0     0.0     0.0      1.8    72.5
13  4 77 103  3 2200 10.0     16.4    16.3     0.0      0.0     0.0      0.0     0.0     0.0      0.4    23.3
13  4 77 103  4 2200 10.0     15.6    12.7     0.0      0.0     0.0      0.0     0.0     0.0      0.2    17.9
13  4 77 103  6 2200 10.0     15.1     4.6     0.0      0.0     0.0      0.0     0.0     0.0      0.0     6.6
13  4 77 103  7 2200 10.0     17.0     7.9     0.3      0.0     0.0      0.0     0.0     0.0      0.2    11.2
13  4 77 103  9 2200 10.0     16.6    14.5     1.0      0.0     0.0      0.0     0.0     0.0      0.7    21.1
13  4 77 103 12 2200 10.0     25.5    89.1   174.8     45.8   130.9      0.0     0.0     0.0    201.9   127.9
13  4 77 103 13 2115 10.0     20.8    13.5     0.0      0.0     0.0    155.6     0.0     0.0      1.3    19.7
13  4 77 103 14 2200 10.0     34.6    45.9     0.9      5.4    21.7      0.0     0.0     0.0      1.5    65.9
 12
14  4 77 104  3 1000 10.0     15.2     8.8     0.0      2.8     0.0      0.0     0.0     0.0      0.0     0.0
14  4 77 104  4 1300  7.0     15.7     7.3     0.0      1.0     0.0      0.0     0.0     0.0      0.0     0.0
14  4 77 104  5 1000 10.0     14.7     5.0     0.0      0.2     0.0      0.0     0.0     0.0      0.0     0.0
14  4 77 104  6 1000 10.0     15.0     3.1     0.0      0.0     0.0      0.0     0.0     0.0      0.0     0.0
14  4 77 104  7 1000  6.0     15.2     5.3     0.0      0.0     0.0      0.0     0.0     0.0      0.0     0.0
14  4 77 104  8 1000 10.0     15.3     9.0     0.0      1.0     0.0      0.0     0.0     0.0      0.0     0.0
14  4 77 104  9 1000 10.0     15.8     9.4     0.0      0.2     0.0      0.0     0.0     0.0      0.1     0.0
14  4 77 104 10 1000 10.0     16.8    16.0     0.0     11.0     0.0      4.7     0.0     0.0      0.0    14.4
14  4 77 104 11 1000 10.0     17.2    14.8     0.0      1.5     0.7      0.6     0.0     0.0      2.6     1.8
14  4 77 104 12 1000 10.0     17.2    58.4     0.0     47.5     4.8      0.0     0.0     0.0      1.1     0.0
14  4 77 104 13  915 10.0     18.4    10.5     0.0      0.0     1.0      0.0     0.0     0.0      3.9     0.0
14  4 77 104 14 1000 10.0     15.9    22.0     0.0     36.8     0.0      0.0     0.0     0.0      0.0     0.0
 11
14  4 77 104  2 2200 10.0     17.5    27.7     0.0     16.8     0.0      0.0     0.0     0.0      0.0   160.2
14  4 77 104  4 2200 10.0     14.9     0.1     0.0      0.6     0.0      0.0     0.0     0.0      0.0     0.6
14  4 77 104  5 2200 10.0     21.1     0.0     0.0      0.1     0.0      0.0     0.0     0.0      0.0     0.0
14  4 77 104  6 2200 10.0     15.0     0.0     0.0      0.0     0.0      0.0     0.0     0.0      0.0     0.0
14  4 77 104  7 2200 10.0     15.4     0.0     0.0      0.0     0.0      0.0     0.0     0.0      0.0     0.0
14  4 77 104  8 2200 10.0     16.6     0.2     0.0      0.9     0.0      0.0     0.0     0.0      0.0     1.2
14  4 77 104 10 2200 10.0    355.6     2.4     0.0      5.7     5.9     73.7     0.0     0.0      0.0    14.0
14  4 77 104 11 2200 10.0     20.9     1.3     0.0      3.0     0.0    178.8     0.0     0.0      0.4     7.8
14  4 77 104 12 2200 10.0     18.2    49.7     0.0     30.6     0.0      0.0     0.0     0.0      0.0   292.7
14  4 77 104 13 2115 10.0     17.9     0.5     0.0      0.6     6.9      0.0     0.0     0.0      0.0     2.9
14  4 77 104 14 2200 10.0     17.5     7.7     0.0   1282.4     2.4      0.0     0.0     0.0      2.8    45.2
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2of7

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DD MM YY JDY REC   HR SHRS      OBS    PUFF2    PLUME   MSPUFF     RTM2     RADM     ****     ****    PUFF1     ARM3
 12
15  4 77 105  3 1000 10.0     17.7      3.5      0.0      1.6      0.3      0.0      0.0      0.0      0.0      0.0
15  4 77 105  4 1000 10.0     15.3      2.5      0.0      2.2      0.0      0.0      0.0      0.0      0.0      0.0
15  4 77 105  5 1000 10.0     15.3      0.9      0.0      0.6      0.0      0.0      0.0      0.0      0.0      0.0
15  4 77 105  6 1000 10.0     15.4      0.2      0.0      0.3      0.0      0.0      0.0      0.0      0.0      0.0
15  4 77 105  7 1000 10.0    112.3      0.4     25.1      0.9     25.3      0.0      0.0      0.0     37.5      0.0
15  4 77 105  8 1000 10.0    136.5      6.1    320.5      2.2    226.7   2546.1      0.0      0.0    607.4    353.4
15  4 77 105  9 1000 10.0    158.8      1.3      0.0      2.4      5.8      0.0      0.0      0.0      0.0      0.0
15  4 77 105 10 1000 10.0     34.0      6.4      0.0      5.3     14.0   1890.6      0.0      0.0      0.0    259.2
15  4 77 105 11 1000 10.0     46.5      3.3      0.0      4.9      0.0    263.2      0.0      0.0      0.0     35.0
15  4 77 105 12 1000 10.0     16.5     26.7      0.0     12.3      0.0      0.0      0.0      0.0      0.0      0.0
15  4 77 105 13  915 10.0     14.5      1.0      0.0      2.8      0.0     11.0      0.0      0.0      0.0      1.6
15  4 77 105 14 1000 10.0     16.1     13.3      0.0      5.3      0.9      0.0      0.0      0.0      0.0      0.0
 10
15  4 77 105  3 2200 10.0     15.4      8.0      0.0      8.1     27.8      0.0      0.0      0.0      0.0      0.0
15  4 77 105  4 2200 10.0     16.2      6.1      0.0     11.3      1.2      0.0      0.0      0.0      0.0      0.0
15  4 77 105  6 2200 10.0     15.1      5.2      0.0      1.3      1.5      0.0      0.0      0.0      0.0      0.0
15  4 77 105  8 2200 10.0     42.6     43.7    108.7      3.9     87.8   1295.1      0.0      0.0     14.4    213.5
15  4 77 105  9 2200 10.0     25.1      4.9      0.1      5.0      3.4     21.6      0.0      0.0      0.0      0.0
15  4 77 105 10 2200 10.0     17.1     11.6      0.0      5.2      0.3      0.0      0.0      0.0      0.0      0.0
15  4 77 105 11 2200 10.0     15.5      7.0      0.0      6.0      0.0    193.6      0.0      0.0      0.0      0.0
15  4 77 105 12 2200 10.0     15.3     16.6      0.0      4.5      0.0      0.0      0.0      0.0      0.0      0.0
15  4 77 105 13 2115 10.0     15.7      3.2      0.0      5.6      0.0    137.5      0.0      0.0      0.0      0.0
15  4 77 105 14 2200 10.0     36.2     15.3      0.0     13.3     13.4    565.7      0.0      0.0      0.0      0.0
  1
17  4 77 107 14 2200 10.0   1055.9    145.5      0.0      0.0     65.8  46384.1      0.0      0.0      0.0      0.0
 11
18  4 77 108  2 1000 10.0     79.4    458.7      0.0      0.7      0.9   1268.7      0.0      0.0      0.0    497.5
18  4 77 108  3 1000 10.0     16.1     74.9      0.0    154.0      0.0      0.0      0.0      0.0      0.0     83.4
18  4 77 108  4 1000 10.0     15.9     15.2      0.0     13.5      0.0      0.0      0.0      0.0      0.0     17.2
18  4 77 108  5 1000 10.0     17.1      0.1      0.0    157.5      0.0      0.0      0.0      0.0      0.0      0.1
18  4 77 108  6 1000 10.0     15.7      0.0      0.0    190.5      0.0      0.0      0.0      0.0      0.0      0.0
18  4 77 108  7 1000 10.0     19.5      0.0      0.0     48.1      0.0      0.0      0.0      0.0      0.6      0.0
18  4 77 108  8 1000 10.0     18.6      0.0      7.2    169.8      0.3      0.0      0.0      0.0      4.7      0.0
18  4 77 108  9 1000 10.0     16.6      0.0    148.5     20.2     24.6      0.0      0.0      0.0     52.5      0.0
18  4 77 108 11 1000 22.0     18.5      0.0    371.0      5.5    126.6      0.0      0.0      0.0    111.0      0.0
18  4 77 108 12 1000 10.0     85.2      0.9      0.0      0.0      3.3      0.0      0.0      0.0      0.0      1.0
18  4 77 108 13  915 12.0     15.5      0.0    303.6      0.0     93.6      0.0      0.0      0.0    115.6      0.0
  6
18  4 77 108  2 2200 10.0     18.1    330.3      0.0      5.3      0.0     76.6      0.0      0.0      0.0      0.0
18  4 77 108  3 2200 10.0     15.8      2.1      0.0     17.0      0.0      0.0      0.0      0.0      0.0      0.0
18  4 77 108  4 2200 10.0     15.7      3.8      0.0      2.6      0.0      0.0      0.0      0.0      0.0      0.0
18  4 77 108  5 2200 10.0     16.9      0.0      0.0      9.5      0.0      0.0      0.0      0.0      0.0      0.0
18  4 77 108 10 2200 10.0     15.9      0.0      0.0    209.5     78.7      0.0      0.0      0.0      0.0      0.0
18  4 77 108 13 2115 10.0     17.7      0.0      0.0     85.8      0.4      0.0      0.0      0.0      0.0      0.0
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DD MM YY JDY REC HR   SHRS      OBS     PUFF2     PLUME    MSPUFF      RTM2      RADM      ****      ****     PUFF1      ARM3
 11
19  4 77 109  2 1000 10.0      16.1       0.0       0.0       0.1       0.0      16.4       0.0       0.0       0.0       0.0
19  4 77 109  3 1000 10.0      15.4       0.0       0.0       0.3       0.0       0.0       0.0       0.0       0.0       0.0
19  4 77 109  5 1000 10.0      15.4       0.0       0.0       0.1       0.0       0.0       0.0       0.0       0.0       0.0
19  4 77 109  7 1000 10.0      15.5       0.0       0.0     112.7       0.0       0.0       0.0       0.0       0.0       0.0
19  4 77 109  8 1000 10.0      16.1     544.7       0.0     349.8       9.4    1119.2       0.0       0.0       0.0     935.4
19  4 77 109  9 1000 10.0     107.2     174.3       8.0     777.6     118.3      22.4       0.0       0.0       0.0     301.4
19  4 77 109 10 1000 10.0     145.4     174.0    3298.5     582.2    1044.9     716.2       0.0       0.0     248.5     301.9
19  4 77 109 11 1000 27.0      30.0     221.9    1603.2     405.5     355.3       0.0       0.0       0.0     479.3     370.7
19  4 77 109 12 1000 10.0      21.2     144.0       0.0       1.0       0.0       0.0       0.0       0.0       0.0     242.6
19  4 77 109 13  915 10.0     279.6       0.0     866.9     166.3     620.9       0.0       0.0       0.0    1012.5       0.0
19  4 77 109 14 1000 10.0      15.9       0.0       0.0       1.1       0.6       0.0       0.0       0.0       0.0       0.0
  9
19  4 77 109  2 2200 10.0      17.2       5.6       0.0       1.3       0.0       0.0       0.0       0.0       0.0       0.6
19  4 77 109  3 2200 10.0      15.7       0.0       0.0       1.4       0.0       0.0       0.0       0.0       0.0       0.6
19  4 77 109  4 2200 10.0      15.6       0.0       0.0       0.6       0.0       0.0       0.0       0.0       0.0       0.2
19  4 77 109  7 2200 10.0      15.5       0.3       0.0      51.4       0.0       0.0       0.0       0.0       0.0      21.4
19  4 77 109  8 2200 10.0      16.5      68.7       0.0     102.2       0.0     116.6       0.0       0.0       0.0      42.2
19  4 77 109  9 2200 10.0      17.4     740.7       0.0     401.8       0.2      34.4       0.0       0.0       0.0     161.3
19  4 77 109 12 2200 10.0      17.7     125.8       0.0      62.6       0.0       0.0       0.0       0.0       0.0      25.3
19  4 77 109 13 2115 10.0      25.4     122.8     115.9     166.5     108.9       0.0       0.0       0.0     161.8      67.7
19  4 77 109 14 2200 10.0      17.6      12.2       0.0    1037.8       5.3     104.4       0.0       0.0       0.0     429.7
 12
20  4 77 110  2 1000 10.0      15.8       5.4       0.0    2327.2       3.0       0.0       0.0       0.0       0.0     371.6
20  4 77 110  3 1000 10.0      15.7       0.0       0.0      14.2       0.0       0.0       0.0       0.0       0.0       2.2
20  4 77 110  4 1000 10.0      15.7       0.0       0.0       7.7       0.0       0.0       0.0       0.0       0.0       1.2
20  4 77 110  5 1000 10.0      15.5       0.0       0.0       4.8       0.0       0.0       0.0       0.0       0.0       0.7
20  4 77 110  6 1000 10.0      15.3       0.0       0.0       3.1       0.0       0.0       0.0       0.0       0.0       0.5
20  4 77 110  7 1000 10.0      15.6       0.3       0.0       6.1       0.0       0.0       0.0       0.0       0.0       1.0
20  4 77 110  8 1000 10.0      16.0       7.8       0.0      16.8       0.0       0.0       0.0       0.0       0.0       2.6
20  4 77 110  9 1000 10.0      16.3      25.8       0.0      15.5       0.0     320.0       0.0       0.0       0.0       2.4
20  4 77 110 10 1000 10.0    1452.2     107.8       0.0      52.2       0.0     166.9       0.0       0.0       0.0       8.3
20  4 77 110 12 1000 10.0      16.2     137.7     142.4     148.0      28.6     140.4       0.0       0.0       6.8      22.8
20  4 77 110 13  915 10.0      16.8      46.9       0.0      13.0       2.8       0.0       0.0       0.0       0.0       2.0
20  4 77 110 14 1000 10.0      25.6     197.5       0.0    3581.6    2153.5       0.0       0.0       0.0       0.0     568.9
  9
20  4 77 110  2 2200 10.0      16.5       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
20  4 77 110  3 2200 10.0      15.3       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
20  4 77 110  4 2200 10.0      15.6       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
20  4 77 110  6 2200 10.0      16.3       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
20  4 77 110  7 2200 10.0      15.8       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
20  4 77 110  9 2200 10.0      15.6       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
20  4 77 110 11 2200 10.0      17.8       0.0       0.0       0.0       0.0     149.0       0.0       0.0       0.0       0.0
20  4 77 110 12 2200 10.0      87.6     373.3       0.0      47.3      15.8    1405.9       0.0       0.0       2.5       0.0
                                          0.0       0.0       0.0       0.0       4.5       0.0       0.0       0.0       0.0
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DD MM YY JDY REC HR   SHRS    OBS    PUFF2   PLUME  MSPUFF   RTM2    RADM   ****   ****  PUFF1    ARM3
 13
21  4 77 111  2 1000 10.0    15.4     0.0     0.0     0.0     0.0     0.0    0.0    0.0    0.0     0.0
21  4 77 111  3 1000 10.0    15.3     0.0     0.0     0.0     0.0     0.0    0.0    0.0    0.0     0.0
21  4 77 111  4 1000 10.0    17.9     0.0     0.0     0.0     0.0     0.0    0.0    0.0    0.0     0.0
21  4 77 111  5 1000 10.0    15.2     0.0     0.0     0.0     0.0     0.0    0.0    0.0    0.0     0.0
21  4 77 111  6 1000 10.0    15.2     0.0     0.0     0.0     0.0     0.0    0.0    0.0    0.0     0.0
21  4 77 111  7 1000 10.0    15.4     0.0     0.0     0.0     0.0     0.0    0.0    0.0    0.0     0.0
21  4 77 111  8  920 10.0    15.5     0.0     0.0     0.0     0.0     0.0    0.0    0.0    0.0     0.0
21  4 77 111  9 1000 10.0    15.3     0.0     0.0     0.0     0.0     0.0    0.0    0.0    0.0     0.0
21  4 77 111 10 1000 10.0    16.1     0.0     0.0     0.0     0.0     0.0    0.0    0.0    0.0     0.0
21  4 77 111 11 1000 10.0    15.2     0.0     0.0     0.0     0.0     0.0    0.0    0.0    0.0     0.0
21  4 77 111 12 1000 10.0    18.1   797.1  1207.9    85.5   567.9  2380.9    0.0    0.0  557.4  1102.3
21  4 77 111 13  915 10.0    16.5     0.0     0.0     0.0     0.0     0.0    0.0    0.0    0.0     0.0
21  4 77 111 14 1000 10.0   797.2     0.0     0.0     0.0   196.8    83.1    0.0    0.0    0.0     0.0
 10
21  4 77 111  2 2200 10.0    15.3     0.0     0.0     0.0     0.0     0.0    0.0    0.0    0.0     0.0
21  4 77 111  3 2200 10.0    16.9     0.0     0.0     0.0     0.0     0.0    0.0    0.0    0.0     0.0
21  4 77 111  6 2200 10.0    15.2     0.0     0.0     0.0     0.0     0.0    0.0    0.0    0.0     0.0
21  4 77 111  7 2200 10.0    15.4     0.0     0.0     0.0     0.0     0.0    0.0    0.0    0.0     0.0
21  4 77 111  8 2200 10.0    15.3     0.0     0.0     0.0     0.0     0.0    0.0    0.0    0.0     0.0
21  4 77 111  9 2200 10.0    15.2     0.0     0.0     0.0     0.0     0.0    0.0    0.0    0.0     0.0
21  4 77 111 10 2200 10.0    15.2     0.0     0.0     0.0     0.0     0.0    0.0    0.0    0.0     0.0
21  4 77 111 12 2200 10.0    15.7    47.1     2.4   149.3    12.6     0.0    0.0    0.0    5.5    30.5
21  4 77 111 13 2115 10.0    15.5     0.0     0.0     0.0     0.0     0.0    0.0    0.0    0.0     0.0
21  4 77 111 14 2200 10.0    19.8     0.0     0.0     0.0   177.7     0.0    0.0    0.0    0.0     0.0
 12
22  4 77 112  2 1000 10.0    15.2     0.0     0.0     0.0     0.0     0.0    0.0    0.0    0.0     0.0
22  4 77 112  3 1000 10.0    15.3     0.0     0.0     0.0     0.0     0.0    0.0    0.0    0.0     0.0
22  4 77 112  4 1000 10.0    15.2     0.0     0.0     0.0     0.0     0.0    0.0    0.0    0.0     0.0
22  4 77 112  5 1000 10.0    16.3     0.0     0.0     0.0     0.0     0.0    0.0    0.0    0.0     0.0
22  4 77 112  6 1000 10.0    15.2     0.0     0.0     0.0     0.0     0.0    0.0    0.0    0.0     0.0
22  4 77 112  7 1000 10.0    15.6     0.0     0.0     0.0     0.0     0.0    0.0    0.0    0.0     0.0
22  4 77 112  8 1000 10.0    15.2     0.0     0.0     0.0     0.0     0.0    0.0    0.0    0.0     0.0
22  4 77 112  9 1000 10.0    15.2     0.0     0.0     0.0     0.0     0.0    0.0    0.0    0.0     0.0
22  4 77 112 11 1000 10.0    15.2     0.0     0.0     0.0     0.0     0.0    0.0    0.0    0.0     0.0
22  4 77 112 12 1000 10.0    62.2    18.4     8.4     0.0    24.7   230.6    0.0    0.0    0.0     5.4
22  4 77 112 13  915 10.0    15.1     0.0     0.0     0.0     0.0     0.0    0.0    0.0    0.0     0.0
22  4 77 112 14 1000 10.0  1168.3   165.2     0.0     0.0     2.1   190.5    0.0    0.0    0.0    50.0
 13
27  4 77 117  2  900 10.0    15.7     0.0     0.0     0.0     0.0     0.0    0.0    0.0    0.0     0.0
27  4 77 117  3  900 12.0    15.7     0.0     0.0     0.0     0.0     0.0    0.0    0.0    0.0     0.0
27  4 77 117  4  900 10.0    15.9     0.0     0.0     0.0     0.0     0.0    0.0    0.0    0.0     0.0
27  4 77 117  5  830 10.0    15.6     0.0     0.0     0.0     0.0     0.0    0.0    0.0    0.0     0.0
27  4 77 117  6  900 10.0    15.9    18.8     0.1     8.9    96.5    63.6    0.0    0.0    0.0    28.3
27  4 77 117  7  900 10.0    83.0     0.0     0.0     0.0     0.0     0.0    0.0    0.0    0.0     0.0
27  4 77 117  8  900 22.0    26.8     0.0     0.0     0.0     6.1     0.0    0.0    0.0    1.2     0.0
27  4 77 117  9  900 10.0    15.9     0.0     0.0     0.0     0.0     0.0    0.0    0.0    0.0     0.0
27  4 77 117 10  900 10.0    15.6     0.0     0.0     0.0     0.0     0.0    0.0    0.0    0.0     0.0
27  4 77 117 11  900 10.0    15.9     0.0     0.0     0.0     0.0     0.0    0.0    0.0    0.0     0.0
27  4 77 117 12  900 10.0    15.7     0.0     0.0     0.0     0.0     0.0    0.0    0.0    0.0     0.0
27  4 77 117 13  815 10.0    15.9     0.0     0.0     0.0     0.0     0.0    0.0    0.0    0.0     0.0
27  4 77 117 14  900 10.0    15.9     0.0     0.0     0.0     0.0     0.0    0.0    0.0    0.0     0.0
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DD MM YY JDY REC HR   SHRS     OBS     PUFF2    PLUME   MSPUFF    RTM2     RADM     ****     ****    PUFF1     ARM3
  8
27  4 77 117  2 2100 10.0     15.6      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
27  4 77 117  3 2345 10.0     15.6      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
27  4 77 117  6 2100 10.0     15.7      6.1      0.0      0.0      0.0     13.9      0.0      0.0      0.0      0.0
27  4 77 117  9 2100 10.0     41.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
27  4 77 117 10 2100 10.0     18.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
27  4 77 117 11 2100 10.0     16.2      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
27  4 77 117 12 2100 10.0     15.6      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
27  4 77 117 14 2100 10.0     15.5      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 10
28  4 77 118  2 1200  7.0     15.4      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
28  4 77 118  4  90C 10.0     15.6      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
28  4 77 118  5  900 10.0     18.3      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
28  4 77 118  6  900 10.0     15.5      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
28  4 77 118  7  900 10.0    427.4      0.0    320.5    825.8    256.4      0.0      0.0      0.0    282.2      0.0
28  4 77 118  8  900 10.0   1573.6      0.0    312.2    169.9    175.5      0.0      0.0      0.0    249.9      0.0
28  4 77 118  9  900 10.0    132.5      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
28  4 77 118 10  900 10.0     15.6      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
28  4 77 118 12  900 10.0     15.6      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
28  4 77 118 13  815 10.0     15.5      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 12
28  4 77 118  2 2100 10.0     18.3      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
28  4 77 118  3 2100 10.0     17.2      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
28  4 77 118  4 2100 10.0     15.5      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
28  4 77 118  5 2100 10.0     15.9      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
28  4 77 118  6 2100 10.0     15.6      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
28  4 77 118  7 2100 10.0     28.6    178.7      0.0     32.4      3.5    413.8      0.0      0.0      0.5      0.0
28  4 77 118  8 2100 10.0     29.4    115.4     24.6    122.3     27.0    232.1      0.0      0.0     38.6    111.1
28  4 77 118  9 2100 10.0     71.2      0.0     21.5      0.0     65.8      0.0      0.0      0.0     35.3     95.6
28  4 77 118 11 2100 10.0     15.4      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
28  4 77 118 12 2100 10.0     15.4      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
28  4 77 118 13 2015 10.0     17.6      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
28 14 77 118 14 2100 10.0     15.4      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
 12
11  7 77 192  2  900 10.0     15.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
11  7 77 192  3  900 10.0     14.9      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
11  7 77 192  4  900 10.0     14.7      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
11  7 77 192  5  900 10.0     14.8      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
11  7 77 192  7  900 10.0     18.9     84.7    644.8      0.0    462.9      0.0      0.0      0.0   1106.1      0.0
11  7 77 192  8  900 10.0     31.1   2064.6    484.7      0.0    711.4      0.0      0.0      0.0    777.6      0.0
11  7 77 192  9  900 10.0    127.3   1452.5      0.0      0.3    229.9      0.0      0.0      0.0      0.2      0.1
11  7 77 192 10  900 10.0     43.4      0.0      0.0   2347.3      0.2      0.0      0.0      0.0      0.0   1341.4
11  7 77 192 11  900 10.0     15.0      0.0      0.0    213.1      5.5      0.0      0.0      0.0      0.0    122.6
11  7 77 192 12  900 10.0     14.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
11  7 77 192 13  830 10.0     15.0      0.0      0.0     19.6     16.7      0.0      0.0      0.0      1.0     11.5
11  7 77 192 14  900 10.0     15.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
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DD MM YY JDY REC HR   SHRS    OBS   PUFF2   PLUME  MSPUFF   RTM2    RADM    ****    ****   PUFF1    ARM3
 11
11  7 77 192  2 2100  10.0   14.9     0.0     0.0     0.0    0.0     0.0     0.0     0.0     0.0     0.0
11  7 77 192  3 2100  10.0   15.2     0.0     0.0     0.0    0.0     0.0     0.0     0.0     0.0     0.0
11  7 77 192  5 2100  10.0   17.0     0.0     0.0     0.0    0.0     0.0     0.0     0.0     0.0     0.0
11 17 77 192  6 1600  15.0   14.9     0.0     0.0     0.0    0.0     0.0     0.0     0.0     0.0     0.0
11  7 77 192  7 2100  10.0   15.5    79.9     0.7     0.0    9.2  1168.6     0.0     0.0     0.4     0.0
11  7 77 192  8 2100  10.0   15.0   444.2     1.3    17.0    8.3   175.6     0.0     0.0     0.0    24.1
11  7 77 192  9 2100  10.0   18.5   256.0    17.8   198.2   31.9     0.0     0.0     0.0    64.3   275.6
11  7 77 192 11 2100  10.0   22.4    73.8     4.0    90.7   29.8     0.0     0.0     0.0    38.1   126.8
11  7 77 192 12 2100  10.0   14.9     0.0     0.0     0.0    0.0     0.0     0.0     0.0     0.0     0.0
11  7 77 192 13 2045  10.0   45.2    42.2    55.3    24.9   32.4     0.0     0.0     0.0    85.7    34.9
11  7 77 192 14 2100  10.0   14.8     0.0     0.0     0.0    0.0     0.0     0.0     0.0     0.0     0.0
 11
15  7 77 196  2  900  10.0   16.5     2.0     0.2     0.0    0.0     0.0     0.0     0.0     0.0     0.0
15  7 77 196  3  900  10.0   15.6     0.0     0.0     0.0    0.0     0.0     0.0     0.0     0.0     0.0
15  7 77 196  4  900  10.0   15.6     0.0     0.0     0.0    0.0     0.0     0.0     0.0     0.0     0.0
15  7 77 196  5  900  10.0   15.4     0.0     0.0     0.0    0.0     0.0     0.0     0.0     0.0     0.0
15  7 77 196  7  900  10.0   15.9     0.0     0.0     0.0    0.0     0.0     0.0     0.0     0.0     0.0
15  7 77 196  9  900  10.0   15.8     0.0     0.0     0.0    0.0     0.0     0.0     0.0     0.0     0.0
15  7 77 196 10  900  10.0  239.1     0.0     0.0     0.0    0.0     0.0     0.0     0.0     0.0     0.0
15  7 77 196 11  900  10.0   28.2     0.0     0.0     0.0    0.0     0.0     0.0     0.0     0.0     0.0
15  7 77 196 12  900  10.0   18.7     0.0     0.0     0.0    0.0     0.0     0.0     0.0     0.0     0.0
15  7 77 196 13  845  10.0   15.9     0.0     0.0     0.0    0.0     0.0     0.0     0.0     0.0     0.0
15  7 77 196 14  900  10.0   42.5    15.9     0.4     0.0    2.0    21.6     0.0     0.0     0.0     0.0
 9
15  7 77 196  2 2200  10.0   16.0     7.4     5.7     0.0   27.9     0.0     0.0     0.0    16.1     0.0
15  7 77 196  3 2100  10.0   16.2     0.0     0.0     0.0    0.0     0.0     0.0     0.0     0.0     0.0
15  7 77 196  4 2100  10.0   15.9     0.0     0.0     0.0    0.0     0.0     0.0     0.0     0.0     0.0
15  7 77 196  7 2100  10.0   25.5     0.0     0.0     0.0    0.0     0.0     0.0     0.0     0.0     0.0
15  7 77 196  8 2100  10.0   15.9     0.0     0.0     0.0    0.0     0.0     0.0     0.0     0.0     0.0
15  7 77 196 10 2100  10.0   18.4     0.0     0.0     0.0    0.0     0.0     0.0     0.0     0.0     0.0
15  7 77 196 11 2100  10.0   16.5     0.0     0.0     0.0    0.0     0.0     0.0     0.0     0.0     0.0
15  7 77 196 12 2100  10.0   22.5     0.4     0.0     0.0    0.0     0.0     0.0     0.0     0.0     0.0
15  7 77 196 14 2100  10.0   17.5     0.0     6.3     0.0    1.0    18.2     0.0     0.0     7.9     0.0
 12
18  7 77 199  2  900  10.0   15.2     0.0     0.0     0.0    0.0     0.0     0.0     0.0     0.0     0.0
18  7 77 199  3  900  10.0   15.1     0.0     0.0     0.0    0.0     0.0     0.0     0.0     0.0     0.0
18  7 77 199  4  900  10.0   15.2     0.0     0.0     0.0    0.0     0.0     0.0     0.0     0.0     0.0
18  7 77 199  5  900  10.0   15.2     0.0     0.0     0.0    0.0     0.0     0.0     0.0     0.0     0.0
18  7 77 199  7  900  10.0   15.2     0.0     0.0     0.0    0.0     0.0     0.0     0.0     0.0     0.0
18  7 77 199  8  900  10.0   15.4     0.0     0.0     0.0    0.0     0.0     0.0     0.0     0.0     0.0
18  7 77 199  9  900  10.0   15.2     0.0     0.0     0.0    0.0     0.0     0.0     0.0     0.0     0.0
18  7 77 199 10  900  10.0   15.3     0.0     0.0     0.0    0.0     0.0     0.0     0.0     0.0     0.0
18  7 77 199 11 1200   7.0   15.1     0.0     0.0     0.0    0.0     0.0     0.0     0.0     0.0     0.0
18  7 77 199 12  900  10.0   15.9     0.0     0.0     0.0    0.0     0.0     0.0     0.0     0.0     0.0
18  7 77 199 13 1300   5.8   16.1     0.0     0.0     0.0    0.0     0.0     0.0     0.0     0.0     0.0
18  7 77 199 14  900  10.0   36.1     0.0     0.0     0.0    0.0     0.0     0.0     0.0     0.0     0.0
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 MM YY JDY REC HR   SHRS    OBS    PUFF2   PLUME  MSPUFF   RTM2    RADM    ****    ****   PUFF1    ARM3
9
 7 77 199  2 2100  10.0    15.1     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 7 77 199  3 2100  10.0    15.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 7 77 199  4 2100  10.0    15.4     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 7 77 199  7 2100  10.0    15.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 7 77 199  9 2100  10.0    15.3     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 7 77 199 10 2100  10.0    15.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 7 77 199 12 2100  10.0    15.2     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 7 77 199 13 2030  10.0    33.2     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 7 77 199 14 2100  10.0    15.0     0.0     0.0     0.0     0.7     0.0     0.0     0.0     0.0     0.0

 7 77 200  2  900  10.0    15.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 7 77 200  3  900  10.0    15.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 7 77 200  5  900  10.0    14.9     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 7 77 200  7  900  10.0    15.2     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 7 77 200  8  900  10.0    18.1     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 7 77 200  9  900  10.0    15.4     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 7 77 200 10  900  10.0  2275.6     0.0     0.0     0.0    12.8     0.0     0.0     0.0     0.0     0.0
 7 77 200 11  900  10.0  1525.1     0.0     0.0     0.0     0.7     0.0     0.0     0.0     0.0     0.0
 7 77 200 12  900  10.0    15.1     0.0     0.8   605.9    86.5     0.0     0.0     0.0     0.0     0.0
 7 77 200 13  830  12.0    15.4     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 7 77 200 14  900  10.0    15.0     0.0     0.0     0.0   153.2     0.0     0.0     0.0     0.0     0.0

 7 77 200  2 2100  10.0    14.9     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 7 77 200  3 2100  10.0    15.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 7 77 200  4 2100  10.0    15.2     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 7 77 200  5 2100  10.0    15.2     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
 7 77 200 10 2100  10.0    82.4    80.6     0.0     0.0    48.5   180.9     0.0     0.0     0.0     0.0
 7 77 200 14 2100  10.0    15.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0

   77 201  3  900  10.0    15.9     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
   77 201  5  900  10.0    15.1     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
   77 201  7  900  10.0    15.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
   77 201  8  900  10.0    15.3     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
   77 201  9  900   5.0    16.1     0.0     0.0     0.0    53.8     0.0     0.0     0.0     0.0     0.0
   77 201 10  900  10.0    20.0     0.0     0.0     0.0    71.5     0.0     0.0     0.0     0.0     0.0
   77 201 11  900   8.5    18.2    46.9   717.5     0.0   292.0     2.5     0.0     0.0   291.0   175.7
   77 201 12  900  10.0    15.6     0.0     0.0     0.4     0.0     0.0     0.0     0.0     0.0     0.0
   77 201 13  830  10.0    22.8    36.1   178.0     0.0    85.4     0.0     0.0     0.0    47.4    44.8
   77 201 14  900   9.3    15.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0

   77 206  3  900  10.0    15.9     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
   77 206  4  900  10.0    15.9     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
   77 206  5  900  10.0    15.7     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
   77 206  7  900  10.0    16.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
   77 206  8  900  10.0    15.9     0.0     0.0   549.1     0.0     0.0     0.0     0.0     0.0     0.0
   77 206 10  900  10.0   381.9     0.5  2294.7     0.0   807.7    68.0     0.0     0.0  5308.8  1999.7
   77 206 11  900  10.0   104.6     0.0   447.9     0.0   209.1     6.3     0.0     0.0   787.0     0.0
   77 206 12  900  10.0    16.7     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
   77 206 13  830  10.0   169.4     0.0   112.9     0.0    54.7     0.0     0.0     0.0   151.6     0.0
   77 206 14  900  10.0    15.8     0.0     0.0     0.0     1.7     0.0     0.0     0.0     0.0     0.0
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DD MM YY JDY REC HR   SHRS    OBS   PUFF2   PLUME  MSPUFF    RTM2    RADM    ****    ****   PUFF1    ARM3
 9
25  7 77 206  3 2100 10.0    15.9     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
25  7 77 206  4 2100 10.0    18.1     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
25  7 77 206  7 2100 10.0    16.0     0.0     0.0  1199.4     0.0     0.0     0.0     0.0     0.0     0.0
25  7 77 206  8 2100 10.0    15.8     0.0     0.0   263.5     0.1     0.0     0.0     0.0     0.0     0.0
25  7 77 206  9 2100 10.0    18.7   431.4   504.7     0.0   305.5   834.4     0.0     0.0   323.5   529.3
25  7 77 206 10 2100 10.0    29.7    73.4    17.2     0.0     3.8   173.0     0.0     0.0     2.9    90.2
25  7 77 206 11 2100 10.0    31.1   141.1    14.3     0.0    33.2   117.2     0.0     0.0     2.8   172.4
25  7 77 206 12 2100 10.0    15.4     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
25  7 77 206 14 2100 10.0    25.6     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
10
26  7 77 207  3  900 10.0    15.6     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
26  7 77 207  4  900 10.0    15.6     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
26  7 77 207  5  900 10.0    15.9     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
26  7 77 207  7  900 10.0    15.6     0.0     0.0    81.8     5.3     0.0     0.0     0.0     0.0     0.0
26  7 77 207  8  900 10.0    15.7     0.0    28.5   200.6    60.4     0.0     0.0     0.0    24.6     0.0
26  7 77 207  9  900 10.0    15.7    14.3     0.3     0.0    22.7     0.0     0.0     0.0     0.0     3.4
26  7 77 207 10  900 10.0    71.7    29.4     0.0     0.0     0.1     2.1     0.0     0.0     0.0     7.0
26  7 77 207 11  900 10.0    75.2   113.8     0.0     0.0     0.0   472.3     0.0     0.0     0.0    27.1
26  7 77 207 12  900 10.0    14.9     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
26. 7 77 207 13  830 10.0    54.5   512.6     0.0     0.0     0.0   113.7     0.0     0.0     0.0   118.1
11
26  7 77 207  3 2100 10.0    15.3     0.0     0.0     0.0     0.0    19.2     0.0     0.0     0.0     0.0
26  7 77 207  4 2100 10.0    15.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
26  7 77 207  5 2100 10.0    16.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0
26  7 77 207  7 2100 10.0    15.4    12.1     0.0     0.0     0.0     0.0     0.0     0.0     0.0     6.0
26  7 77 207  8 2100 10.0    17.0    17.7     0.0     0.0     3.7   285.1     0.0     0.0     0.0     8.6
26  7 77 207  9 2100 10.0    19.8   127.5    31.2     0.0    14.4   186.1     0.0     0.0    17.4    62.2
26  7 77 207 10 2100 10.0    19.9    28.4     0.0     0.0     7.3     0.0     0.0     0.0     0.0    13.6
26  7 77 207 11 2100 10.0    20.1   118.4     0.0     0.0     1.7   123.1     0.0     0.0     0.0    56.2
26  7 77 207 12 2100 10.0    30.2     2.4     0.0     0.0     0.0     0.0     0.0     0.0     0.0     1.2
26  7 77 207 13 2030 10.0    19.0   148.1     0.0     0.0     0.5   547.7     0.0     0.0     0.0    70.8
26  7 77 207 14 2100 10.0    16.5     1.2     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.6
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